Birck Nanotechnology Center

Equipment Installation Manual

Revised

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TABLE OF CONTENTS

1. INTRODUCTION

1.1. PURPOSE

The Birck Nanotechnology Center Equipment Installation Manual documents the materials, methods, and procedures used to install equipment in the laboratories and cleanrooms of the facility. Compliance to this manual is required to ensure the safety of the employees working in the facility and to support the research that is being performed in the facility.

1.2. SCOPE

This document covers all equipment installations in the Birck Facility, including the cleanroom, laboratories, and subfab. A "new" equipment installation refers to the connection of utilities to: 1) a piece of newly purchased equipment; 2) a piece of equipment moved from a different facility; or 3) a piece of equipment relocated within the facility. New equipment installations are **always** subject to this manual.

An equipment utility "modification" involves the changing of utilities to (or within) a piece of equipment that remains in the same location. If hazardous materials are involved, the modification is **always** subject to this manual. If hazardous materials are not involved, it is **recommended** that this manual be followed.

NOTE: Hazardous production material (HPM) is defined by the Indiana Fire Code as "A solid, liquid, or gas associated with semiconductor manufacturing that has a degree-of-hazard rating in health, flammability, or reactivity of Class 3 or 4 as ranked by UFC Standard 79-3 and which is used directly in research, laboratory or production processes which have as their end product materials which are not hazardous." This definition is implied when the term *hazardous materials* is used in this manual.

Please note that this manual covers "connection of utilities" to equipment, but does not cover utilities within the equipment. It is recommended, however, that the same principles apply to internal utilities. This will enhance both the safety and cleanliness of the equipment.

1.3. EXCEPTIONS TO THE MANUAL

Exceptions to the procedures in this document must be approved in writing by the Birck Facilities Team. The Birck Facilities Team consists of the following:

- Facility Manager
- Zone Maintenance Supervisor
- REM Safety Coordinator
- Building Manager
- Equipment and Process Manager

Application for a variance is obtained by filling out the Variance Form located in Section 6 of this document. The Birck Facilities Team will be convened and the case presented by the applicant. If agreed upon by the team, the variance will be signed and the exception to the manual will stand for the agreed-upon time period.

Existing conditions may be "grandfathered" (i.e., allowed to exist in its current condition, even though it does not comply with this document) at the discretion of the engineer responsible for that equipment and the Birck Facilities Team.

NOTE: The minimum acceptable installations must always comply with current state and federal codes. Beyond this, all installations must at least meet current industry standards and the requirements of the Purdue REM Department. No grandfathering or variance shall be allowed to exist which would compromise the safety of anyone in the facility, even for a limited time.

1.4. GENERAL PHILOSOPHY

The Birck Facility is divided into two distinct research areas, the laboratories and the cleanrooms. The needs of these two areas are similar, but there are distinct differences in the requirements of each area. Even within each of these areas there are significant differences in requirements. Each of the laboratories will not have the same requirements, and the needs of the bio-cleanroom are quite different from the needs of the nanofabrication cleanroom. It is important that the options offered in this manual are carefully reviewed, and the appropriate option chosen for the application.

There are two basic goals in equipment installation in the cleanroom. The first goal is to ensure that the equipment installation proceeds without contamination of the operational cleanroom and/or adjacent equipment. The second goal is to ensure that the equipment being installed, the surrounding area, and the utilities provided to the equipment are contamination-free. Care must be taken in the installation to successfully accomplish both of these goals.

The key to all equipment-installation activity in the cleanroom is to THINK CLEAN. The individual performing a task is generally going to be the most creative in identifying a cleaner way to do his/her job. If that is constantly kept in mind, the cleanliness level of the facility will continue to increase.

Many utilities are in intentional contact with the product, making their cleanliness and purity even more important than the cleanroom air. Methods must be used to ensure that the piping, etc., that carries those utilities is not contaminated during equipment installation.

The “dirtier” an equipment-installation operation must be, the more important the isolation of that activity becomes. For example, threading a pipe is by nature a dirty operation, and must be performed as far from the cleanroom as practical. Also, proper methods must be used to clean the pipe after threading to help prevent contaminants from entering the cleanroom or the interior surfaces of the piping.

The closer to the operational cleanroom that a task must be performed, the more critical the practice used in performing that task. It must be remembered, however, that all airflow in the cleanroom area goes to a common plenum and therefore clean methods must be practiced every place within the perimeter of the cleanroom (including the chases).

2. SYSTEMS DESCRIPTIONS

2.1. SAFETY SYSTEMS

2.1.1. Emergency Gas Shutoff System

The emergency gas shutoff system is a pressurized loop that is tied to normally-closed valves on hazardous bulk gases entering the Birck Nanotechnology Center. The system has emergency shutoff stations of the break-glass type located at strategic points around the facility. When the button is activated, the pressurized loop vents, thus closing the normally-closed valves and shutting off the supply of hazardous gases to the facility.

The system is constructed of cleaned and capped seamless copper tubing Type K or L, sweated connections in basement and to the chase wall. If in cleanroom, Swagelok or A-Lok fittings to PFA tubing are allowed. PFA tubing must not penetrate the chase wall unless a smooth grommet is used to protect the tubing. Brass ball valves are acceptable. No filtration is required.

2.1.2. Toxic Gas Monitoring System

The TGM system is a hazardous gas monitoring system. The main system is an MDA Vertex system, tied to a PLC controller. It has four types of sensors - hydride, oxidizer, mineral acid, and pyrolyzer + mineral acid – and pressure monitors for the interstitial area between the carrier tubing and the containment tubing..

All hazardous gases must be monitored at the source and at the point of use. A gas is considered hazardous if one or more of its hazard ratings – health, flammability, or reactivity – are 3 or above. These ratings can be obtained from the MSDS for that gas.

The hazard ratings of any gases being installed must be reviewed to ensure that gas detection decisions are made properly.

The alarm matrix for this system is as follows:

TGM Response Matrix

Action	Siemens Bldg. Mgt. Sys.		All Local Horns & Strobes	TGM Monitoring PLC	Remote Toxic Gas Annunciator Panel	Shut Down All Gas Cabinets	Remote Alarm (Campus Police)		Building Alarm (Evacuation) [To Simplex]
	Danger	Fault					Danger	Fault	
Pushbutton	♦		♦	♦	♦	♦	♦		♦
Low Level Alarm		♦		♦	♦			♦	
High Level Alarm	♦		♦	♦	♦	♦	♦		♦
Low Pressure Alarm - Containment		♦		♦	♦			♦	
High Pressure Alarm - Containment		♦		♦	♦			♦	
Zero Pressure Alarm - Containment	♦		♦	♦	♦	♦	♦		♦
System Trouble		♦		♦	♦			♦	

2.1.3. Containment Pressure Monitoring System

The containment interstitial between the carrier tubing and the containment tubing is to be continuously monitored, and alarm signals from this monitoring are to be tied into the toxic gas monitoring system (TGM) and shall trigger alarms according to the above matrix.

Three conditions are to be detected. High pressure in the interstitial indicates a leak in the carrier pipe, contained by the outer containment piping. Low pressure in the interstitial indicates a leak in the containment piping. Zero (atmospheric) pressure in the containment piping indicates a catastrophic failure of the system, a breach in both the containment and carrier tubing. This indicates a potential for hazardous gases to escape to the atmosphere. The first two conditions trigger a corrective action, the third condition triggers a full evacuation of the facility.

Containment Interstitial Pressure Settings and Alarms

Gas Formula	Gas Name	Cylinder Pressure (psig)	Regulated Pressure (psig)	Containment Pressure (psig)	Containment High Alarm (psig)	Containment Low Alarm (psig)
NF_3	Nitrogen Trifluoride	1450	20	10	15	5
CL_2	Chlorine	85	20	10	15	5
HCl	Hydrogen Chloride (anhydrous)	613	50	25	37.5	12.5
NH_3	Ammonia (anhydrous)	114	50	25	37.5	12.5
NO_2	Nitrous Oxide	660	30	15	22.5	7.5
NO	Nitric Oxide	500	50	25	37.5	12.5
$Kr:F_2$	Krypton:Fluorine	1300	20	10	15	5
SiH_2Cl_2	Dichlorosilane	9	25	12.5	18.75	6.25
PH_3	Phosphine	594	50	25	37.5	12.5
SiH_4	Silane	275	50	25	37.5	12.5
GeH_4	Germane	88	20	10	15	5
$SiH(CH_3)_3$	Trimethyl Silane	25	15	7.5	11.25	3.75

2.1.4. Alarm Tone System

This section to be added at a future date

2.2. HIGH-PURITY GASES

High-purity gas installations are for the use of critical gases, gases that are in intentional contact with product wafers (or other product surfaces), in applications where the ultimate in purity is required. High-purity installations are significantly more expensive than standard installations, but significant reduction in moisture and other impurities are expected. These reductions will enable research that might otherwise be impractical or yield misleading results. Please note that particle reduction should not drive the use of high-purity gases. Particle reduction can be achieved through point-of-use filtration, a far less expensive solution.

The decision to use ultra-high-purity gas installations should be made jointly between the equipment Person-In-Charge (PIC) and the BNC staff. The rationale for the decision should include the requirements of the equipment and the process as well as the function of the fluid.

2.2.1. HP Nitrogen

UHP stainless steel tubing (see Section 3), all welded construction to the tool connection using UHP welding procedures (see Section 4). Turns in UHP stainless steel tubing should utilize welded 90-degree and 45-degree elbows when practical. Bending of tubing less than 3/8” diameter is allowed provided the minimum bend radius is 10x the tubing diameter. Isolation valves are to be UHP diaphragm valves with purge ports. Regulators must be UHP-type, with a downstream in-line filter. Filters, when required, must be either welded into the line or attached with VCR-type connections. Connection is made through a high-purity valve stick consisting of a valve, regulator, gauge, and filter.

2.2.2. HP Argon

UHP stainless steel tubing (see Section 3), all welded construction to the tool connection using UHP welding procedures (see Section 4). Turns in UHP stainless steel tubing should utilize welded 90-degree and 45-degree elbows when practical. Bending of tubing less than 3/8” diameter is allowed provided the minimum bend radius is 10x the tubing diameter. Isolation valves are to be UHP diaphragm valves with purge ports. Regulators must be UHP-type, with a downstream in-line filter. Filters, when required, must be either welded into the line or attached with VCR-type connections. Connection is made through a high-purity valve stick consisting of a valve, regulator, gauge, and filter.

2.2.3. HP Oxygen

UHP stainless steel tubing (see Section 3), all welded construction to the tool connection using UHP welding procedures (see Section 4). Turns in UHP stainless steel tubing should utilize welded 90-degree and 45-degree elbows when practical. Bending of tubing less than 3/8” diameter is allowed provided the minimum bend radius is 10x the tubing diameter. Isolation valves are to be UHP diaphragm valves with purge ports. Regulators must be UHP-type, with a downstream in-line filter. Filters, when required, must be either welded into the line or attached with VCR-type connections. Connection is made through a high-purity valve stick consisting of a valve, regulator, gauge, and filter.

2.2.4. HP Hydrogen

UHP stainless steel tubing (see Section 3), all welded construction to the tool connection using UHP welding procedures (see Section 4). Turns in UHP stainless steel tubing should utilize welded 90-degree and 45-degree elbows when practical. Bending of tubing less than 3/8” diameter is allowed provided the minimum bend radius is 10x the tubing diameter. Isolation valves are to be UHP diaphragm valves with purge ports. Regulators must be UHP-type, with a downstream in-line filter. Filters, when required, must be either welded into the line or attached with VCR-type connections. All non-welded joints must be enclosed in a secondary-containment enclosure (e.g., valve box). Connection is made through a high-purity valve stick consisting of a valve, regulator, gauge, and filter. Valve stick is contained in an exhausted enclosure, monitored by the Toxic Gas Monitoring system (TGM).

2.2.5. HP Gas Cabinet – Hazardous

UHP stainless steel tubing (see Section 3) with contiguous stainless steel secondary containment, all welded construction to the tool connection using UHP welding procedures (see Section 4). Turns in UHP stainless steel tubing should utilize welded 90-degree and 45-degree elbows when practical. Bending of tubing less than 3/8” diameter is allowed provided the minimum bend radius is 10x the tubing diameter. Isolation valves are to be UHP diaphragm valves with purge ports. Regulators must be UHP-type, with a downstream in-line filter. Filters, when required, must be either welded into the line or attached with VCR-type connections. All non-welded joints must be enclosed in a secondary-containment enclosure (e.g., valve box). Connection is made through a high-purity valve stick consisting of a valve, regulator, gauge, and filter. Valve stick is contained in an exhausted enclosure, monitored by the TGM.

2.2.6. HP Gas Cabinet or Gas Stand – Non-Hazardous

UHP stainless steel tubing (see Section 3) with contiguous stainless steel secondary containment, all welded construction to the tool connection using UHP welding procedures (see Section 4). Turns in UHP stainless steel tubing should utilize welded 90-degree and 45-degree elbows when practical. Bending of tubing less than 3/8" diameter is allowed provided the minimum bend radius is 10x the tubing diameter. Isolation valves are to be UHP diaphragm valves with purge ports. Regulators must be UHP-type, with a downstream in-line filter. Filters, when required, must be either welded into the line or attached with VCR-type connections. Connection is made through a high-purity valve stick consisting of a valve, regulator, gauge, and filter.

2.3. STANDARD GAS INSTALLATIONS

Standard gas installations are available for gas-cabinet or gas-stand gases only, due to the risk of contaminating bulk gas sources if this type of installation is used on bulk gas lines. While this type of installation provides reasonable purity levels of the gas, it is not for extremely critical applications.

NOTE: Gas Stand refers to a gas cylinder secured to a semi-permanent fixture which may or may not include a regulator and purging system.

2.3.1. Gas Cabinet – Hazardous

UHP stainless steel tubing (see Section 3), all welded construction to the tool connection. UHP diaphragm valves with purge ports recommended, other cleaned stainless steel valves acceptable. Regulators of UHP-type recommended, other stainless-steel regulators acceptable. A downstream in-line filter is recommended. Filters, when required, must be either welded into line or with VCR-type connection. All non-welded joints must be enclosed in a secondary-containment enclosure (e.g., valve box).

2.3.2. Gas Cabinet or Gas Stand – Non-hazardous

For non-critical, non-hazardous gas cabinet or gas stand applications, flexible (e.g., PFA) tubing may be used. Non-metallic lines may not penetrate walls or floor without suitable protection, such as escutcheon plate or grommet, to prevent abrasion of the tubing.

2.4. OTHER GASES

2.4.1. Utility Nitrogen

Utility nitrogen is designed for operation of valves and other non-product-contact applications. Contaminants in this system are not monitored or controlled, so the consistency of cleanliness and purity levels cannot be depended upon.

Cleaned and capped seamless copper tubing, Type K, with sweated joints in the subfab and to the chase wall. VCR-type and compression fittings to copper tubing are acceptable. In cleanroom, compression fittings to PFA tubing are acceptable. PFA tubing must NOT penetrate waffle slab, raised floor, lab wall, or chase wall. Brass valves are acceptable. Stainless steel or plastic regulators are acceptable. Filters, if needed, may be disposable assemblies or replaceable-media type.

Utility nitrogen is connected to the tool through a utility valve stick consisting of a brass valve, brass regulator, gauge, and VCR-fitting filter (optional).

2.5. *LIQUID SUPPLY SYSTEMS*

2.5.1. Deionized Water

High Purity PVDF piping (see Section 3). IR Butt-Fusion to tool, no threaded joints allowed. Valves are to be high purity (HP) PVDF diaphragm valves. Flowmeters must be HP with PVDF ends. Filters are to be used only when absolutely necessary – permission of DI Water coordinator required; housing must be PVDF with fused connections. O-ring must be Viton™ or PFA-encapsulated Viton™. Hook-up designs must maintain turbulent flows and prevent dead legs.

2.5.2. Domestic Cold Water (potable)(unburied service)

Drawn Type L copper pipe or schedule 80 PVC pipe to chase wall. Swagelok™-type fittings on copper, glued socket connections on PVC. Direct connection to tool or PFA or Polyflo™ tubing inside cleanroom. Threaded adapters allowed. PFA or Polyflo™ tubing may not penetrate waffle slab, raised floor, lab wall, or chase wall. Brass ball valves and regulators are required. If filtration required, use polypropylene housing.

2.5.3. Laboratory Cold Water (unburied service)

Drawn Type L copper pipe or schedule 80 PVC pipe to chase wall. Swagelok™-type fittings on copper, glued socket connections on PVC. Direct connection to tool or PFA or Polyflo™ tubing inside cleanroom. Threaded adapters allowed. PFA or Polyflo™ tubing may not penetrate waffle slab, raised floor, lab wall, or chase wall. Brass ball valves and regulators are required. If filtration required, use polypropylene housing**.**

2.5.4. Laboratory Hot Water (unburied service)

Drawn Type L copper pipe or schedule 80 CPVC pipe to chase wall. Swagelok™-type fittings on copper, glued socket connections on CPVC. Direct connection to tool or PFA or Polyflo™ tubing inside cleanroom. Threaded adapters allowed. PFA or Polyflo™ tubing may not penetrate waffle slab, raised floor, lab wall, or chase wall. Brass ball valves and regulators are required. If filtration required, use polypropylene housing.

2.5.5. Tempered Water Supply (for safety showers and eye washes)

Stainless steel (in cleanroom) or galvanized pipe (outside of cleanroom). Threaded connections allowed.

2.5.6. Process Cooling Water Supply and Return

Schedule 80 PVC pipe to chase wall. Glued socket connections on PVC. Direct connection to tool or PFA or Polyflo™ tubing inside cleanroom. Threaded adapters allowed. PFA or Polyflo™ tubing may not penetrate waffle slab, raised floor, lab wall, or chase wall. PVC ball or diaphragm valves and regulators when required. A rotameter, supply gauge, and return gauge are required at each point of use. If filtration is required, use polypropylene housing. IMPORTANT NOTE: Return may **never** be diverted to drain!

2.5.7. Closed-Loop Cooling Water (Neslab)

Schedule 80 PVC pipe to chase wall. Glued socket connections on PVC. Direct connection to tool or PFA or Polyflo™ tubing inside cleanroom. Threaded adapters allowed. PFA or Polyflo™ tubing may not penetrate waffle slab, raised floor, lab wall, or chase wall. PVC ball or diaphragm valves and regulators are required. If filtration required, use polypropylene housing.

2.5.8. Liquid Nitrogen Supply System

Piping system must be Vacuum Barrier Systems (VBS). **Double-wall pipe:** Two concentric, corrugated tubes, separated by a Teflon™ spacer. The exterior surface of the outer tube shall be coated with plastic. The annular space shall be continuously evacuated to 0.5 microns absolute or better. **Phase separator:** The phase separator shall be a vacuum-insulated Dewar-type vessel fabricated of stainless steel and shall include an inlet bayonet connection, an automatic valve, and inlet relief valve, a reservoir relief valve, a vacuum zone valve, and a vent terminating in a male bayonet connection. **Valves:** All valves shall be compatible with the overall system. Valves in contact with the liquid nitrogen must be stainless steel with non-rising stem, vacuum jacketed, properly rated pressure-relief valve, and with bayonet connections. End-connections use threaded valves. Vacuum shut-off valves may be brass. Connections to this system must be approved by Tim Miller or Dave Lubelski.

2.6. *HOUSE VACUUM SYSTEMS*

2.6.1. Process Vacuum

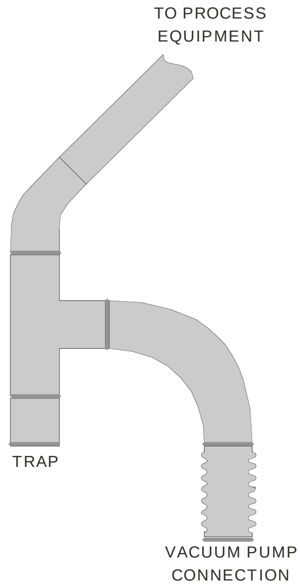
Subfab and Chase: Schedule 80 PVC pipe, glued connections, through chase wall. **Cleanroom:** Brass threaded/Swagelok transition to PFA or Polyflo tubing at chase wall; tubing may not penetrate waffle slab, raised floor, lab wall, or chase wall unless protected by a smooth grommet. PFA or Polyflo tubing or Glued PVC Schedule 80 pipe inside cleanroom. Swagelok or A-Lok joints allowed. PVC ball, plug, or diaphragm valves and brass ball or plug valves are acceptable. No filtration is required.

2.7. *MECHANICAL VACUUM PUMP SYSTEMS*

2.7.1. Roughing Pump Systems

Welded stainless steel; direct connection to the equipment is preferred; approved solvent-resistant flex connections are allowed; flex connection may not penetrate chase wall. Stainless steel bellows is required at the inlet of the pump – the pump side of the bellows must be tied to the vacuum pump or a vacuum pump stand, the equipment side of the bellows must be rigidly tied to the waffle slab, a basement column, or the basement floor. NOTE: Copper lines may be used on evaporators and sputterers only, with the consensus approval of the BNC staff and equipment PIC.

Particle traps are to be used in any system in which the process generates particles. The following diagram indicates a particle trap installation.



2.8. DRAIN SYSTEMS

2.8.1. Acid Waste Drain - Gravity

Labline™ or flame-retardant polypropylene piping, direct connection to tool is required. Traps to be provided in all drain lines.

2.8.2. Acid Waste Drain – Pressurized (pumped)

PVC pipe, schedule 80, with socket-type solvent-weld joints. Double-containment required.

2.9. AIR-HANDLING SYSTEMS

2.9.1. Balancing Boxes

Balancing boxes are provided to distribute air from main trunk lines to individual filter modules. Each balancing box must have an individually controlled manual damper.

Balancing boxes are constructed of galvanized sheet metal, all seams welded and airtight.

2.9.2. Flexible Ductwork

Flexible ductwork must have a flame-spread rating of not more than 25 and a smoke-spread rating of not more than 50.

2.9.3. Filter Modules

Filter modules must be of the upstream-gel-seal type and must fit the standard Birck Nanotechnology Center ULPA filter design. They must have a 3/8-inch polyurethane gasket to the T-bar. Polyurethane gel must be used to make the upstream filter seal.

2.10. EXHAUST SYSTEMS

2.10.1. Scrubbed (Acid) Exhaust

Main ductwork and equipment connections are ATS, Inc. #4910CR fiberglass-reinforced plastic (FRP), Factory Mutual Approved for use without internal sprinklers. Flexible connection requires Teflon-lined stainless steel bellows or W.L. Gore® all-Teflon® bellows. Hook-up to a combustible tool requires rigid duct connection with FM-approved materials. See NFPA 318: Fire Standard for Cleanrooms for more detail. (NFPA 318 is available through the NFPA/ PO Box 9101/ Quincy, MA 02269-9101)

2.10.2. General Exhaust

Riveted galvanized sheet metal or stainless steel, direct connection to gas cabinets required. Stainless steel is required above cleanroom floor.

2.11. ELECTRICAL SYSTEMS

2.11.1. 120/208-volt and 277/480-Volt Busway

No special considerations are listed at this time.

2.11.2. Control Cables

Control cables are specific to individual pieces of equipment, and connect equipment components together. These cables, whenever practical, are to be run beneath the raised floor in the cleanroom area and are to be appropriately clamped or located in cable trays in the subfab. When necessary, they may be run overhead in the chase areas of the cleanroom, and must be appropriately clamped or located in cable trays.

3. DESIGN AND MATERIALS SELECTION

3.1. EQUIPMENT LOCATION AND PLACEMENT

Placement of equipment in the cleanroom is a very critical issue relating to airflow and the ultimate cleanliness capability of the area surrounding the equipment. When evaluating the placement of equipment, several factors must be taken into account. They include the size and shape of the equipment, the access required to operate and service the equipment, the location and number of utility connections to the equipment, and the amount of support equipment located near the equipment and how it connects to the equipment.

Equipment locations must comply with state and federal codes, including but not limited to 36-inch access to electrical panels and aisle-access requirements.

There must be at least 36” clearance in front of gas cabinets and valve-manifold boxes (VMBs).

Most semiconductor equipment designed today is designed for bulkhead mounting – that is to say that the bulk of the equipment resides in the chase with only a small portion (if any) of the equipment located in the cleanroom. Generally, the equipment face is flush with the cleanroom wall. This is the preferred method for equipment placement, and should be used whenever possible. It provides the least interruption of airflow, the best access to the equipment, the simplest connection of utilities, and the highest level of ultimate cleanliness in bare-wafer areas.

Support equipment falls into two classes – contaminating and non-contaminating. Contaminating support equipment must be located in the subfab. Non-contaminating support equipment is to be located in the chase or in the subfab, not in the cleanroom. Locating this equipment in the cleanroom disturbs airflow, requires additional maintenance activities within the cleanest areas, and uses valuable cleanroom floorspace.

The location of support equipment must be carefully planned. Proximity to other utilities – especially vulnerability to leaks and blocking of access routes – is a major consideration.

When equipment cannot be bulkhead mounted, airflow must be taken into consideration. Cripple walls that connect the top of the equipment to the ceiling and allow removal of the ULPA filters created better airflow patterns than having a large horizontal surface with air continually impinging on it. The key in the equipment placement is to ensure that the cleanest air – air coming directly from the ULPA filters without contacting other surfaces – is directed to the most critical areas of the equipment and staging areas.

Any fans, exhausts, etc. in equipment that affect airflow patterns must be located such that adverse effects are eliminated. A successful example involves the ducting of small muffin fan outputs to the chase.

3.1.1. Support Equipment in Subfab

Some support equipment that is most suitably located in the subfab may need to be controlled or adjusted during equipment maintenance activities. To avoid the need of using a second person in the subfab or frequent trips between the subfab and cleanroom, it is sometimes advisable to locate a redundant control panel for the support equipment in the chase. Please note that this must be a redundant panel – the support equipment must be able to be controlled locally as well as remotely. The needs in this area will vary greatly by piece of equipment – the equipment PIC and the BNC staff should make decisions in this regard jointly to ensure maintenance efficiency and minimize expenditure.

3.1.2. Equipment-Support Stands (Pedestals)

Most equipment will be designed to rest on the raised floor. The load-bearing characteristics of the raised floor and the vibration potential of that floor must be considered when making this decision. The primary method of setting equipment not located on the raised floor is to construct a rigid support stand that is suitable for the load-bearing and vibration needs of the particular piece of equipment, customized to the equipment size and support points. This stand rests on the waffle slab and raises the equipment base to the approximate height of the raised floor. The design of the equipment-support stand must be approved by the equipment PIC and the associated BNC staff.

Some support equipment located in the chase may need equipment-support stands as well. This must be considered when developing the location plan for support equipment located in the chase.

3.1.3. Utility Routing and Housekeeping Issues

To maintain control of utility placement, a priority system must be used to ensure that the most efficient routing is possible. In general, exhaust systems get first priority, followed by vacuum pump lines, followed by process piping (high purity then standard utilities), drain lines, then electrical and control lines last. This priority may vary according to the tool – common sense must prevail.

Whether in the cleanroom or the chase, it is critical that all connections to equipment be located far enough above the floor to allow cleaning under them. This includes hard-piped connections and flexible connections. Excess cord or tubing on flexible connections must be secured such that housekeeping is not inhibited.

When dealing with flexible connection, care must be taken to make it as easy as practical for process maintenance to reattach the flexible connections following equipment repair and/or servicing. In chase areas, Velcro straps for connection of flex bundles are a very good solution. In the cleanroom, the use of Velcro is discouraged, but other reusable connectors should be used. Releasable cable ties are a recommended solution.

3.2. ULTRA-HIGH-PURITY GASES

3.2.1. General

All stainless steel tubing, fittings, valves, regulators, filters, and any other components must be compatible with both Parker and Cajon orbital stainless steel welding equipment. All fittings, valves, regulators, filters, and miscellaneous components must have compatible melt temperature with tubing, and must be fully compatible with said tubing.

3.2.2. Stainless Steel Tubing

Stainless steel tubing for ultra-purity service must be seamless tubing up to 1” diameter or seam-welded tubing 1 ½ ” and larger, 316L stainless steel per ASTM A 632 ASTM A 260; bright hydrogen annealed, 20μm maximum surface finish from the extruding mill. Tubing shall have a controlled inside diameter electropolished to a 10 $R_{A\ MAX}$ with a 20 μm (± 10 μm) maximum finish using an electrochemical process with an acid solution and an applied voltage. A sufficient but minimal amount of material must be removed to achieve a smooth, high-luster, uniformly bright surface. After electropolishing, fittings must be thoroughly rinsed with clean water and finally rinsed and wiped with critical cleanroom wiper (such as Anticon Gold) and suitable solvent. Tubing must be cleaned, capped, and shipped with ends capped and tube filled with an inert gas. The tubing must be encapsulated in sealed plastic bags. Tubing not meeting these incoming quality standards is not to be used – it is to be returned to the supplier for credit.

Ovality of the tubing diameter must be ± 0.005” through 1” diameter tubing and ± 0.010” for 1 ½” to 2” tubing. Tubing wall thickness must conform to the following table, with a tolerance of ± 10% :

Outside Diameter	**Wall Thickness**
¼ ”	0.035”

$^{3}/_{8}$ ”	0.035”
½ ”	0.049”
¾ ”	0.065”
1” to 2”	0.065”

Approved Suppliers:

Cardinal Systems Company, Tech 50 or Tech 100 process, individually bagged, from George Booth Company

Valex – 401 and 501 BO Grade or higher, cleaned, polished, and bagged.

Tube Services Company.

3.2.3. Stainless Steel Fittings

Weld Fittings

Tube butt-weld fittings are to be electropolished, cleaned, capped, and bagged from vendor. Fitting wall thickness must be the same as the tubing wall thickness wherever possible. Heavier wall thickness, with machined ends compatible with adjoining tube, is acceptable.

The inside diameter of the weld fittings shall be electropolished to a 10 microinch $R_{A\ MAX}$ finish using an electrochemical process with an acid solution and applied voltage. A sufficient but minimal mount of material must be removed to achieve a smooth, high-luster, uniformly bright surface.

All fittings must be tested for leakage by the vendor and certified with a leak rate less than 10^{-8} atmos. cc per second.

Approved suppliers:

Parker ABW, available from George Booth Company

Swagelok MicroFit, available from Indiana Fluid Systems, specify Level 10 processing

Face-Seal Fittings

Welding is the strongly preferred method for joining tubing in ultra-purity installations. The only authorized fittings are face-seal fittings, and they should be used only when necessary. No compression-type fittings (Swagelok, A-Lok, etc.) are allowed.

All fittings must be tested for leakage by the vendor and certified with a leak rate less than 10^{-8} atmos. cc per second.

Approved suppliers:

Parker Vacuseal, available from George Booth Company

Swagelok VCR, available from Indiana Fluid Systems, specify Level 10 processing

3.2.4. Stainless Steel Valves

½” and Smaller Valves

All valves must be packless. Bellows-type valves must have stainless steel bodies and stainless steel bellows. Diaphragm-type valves must be springless, and have stainless steel bodies and stainless steel diaphragm. In both cases, Hastelloy C22 may be substituted for stainless steel if enhanced corrosion resistance is required. Wetted surfaces must be electropolished, where practical. ½" valves must have purge ports terminated in VCR fittings. All valves must be precleaned for ultra-high-purity gas service and shipped to the site in sealed, unopened plastic bags. Valves not meeting these incoming quality standards are not to be used – it is to be returned to the supplier for credit.

Approved suppliers:
AP Tech: SZ series
Swagelok from Indiana Fluid Systems: ¼" HD Series; 3/8" DF Series
Veriflo "I" series
Tescom PV 71 series

¾" Valves

All valves must be bellows-type with 316 stainless steel body, with stainless steel bellows welded to the body. Hastelloy C22 may be substituted for stainless steel if enhanced corrosion resistance is required. They must have purge ports terminated in VCR or Vacuseal fittings. Wetted surfaces must be electropolished where practical. Valves must be precleaned for ultra-high-purity gas service and shipped to the site in sealed, unopened plastic bags. Valves not meeting these incoming quality standards are not to be used – it is to be returned to the supplier for credit. Valves must have 3-inch tube extensions suitable for automatic tube butt-weld system and with tube wall thickness to match the system. ***Approved suppliers:***

Approved suppliers:
Carten HF series
Swagelok series "ELD" [specify SC-01 cleaning] from Indianapolis Fluid Systems
SAES-Parker CvMax 600 series

1" and Larger Valves

All valves must be packless, diaphragm-type valves with 316 stainless steel body with stainless steel diaphragm. Hastelloy C22 may be substituted for stainless steel if enhanced corrosion resistance is required. Wetted surfaces must be electropolished. Valves must be "full port" design with purge ports upstream and downstream. The purge ports must terminate in VCR or Vacuseal caps. Valves must have tube extensions for automatic tube butt-weld system and have a wall thickness compatible with adjoining tubes. Valves must be precleaned for ultra-high-purity gas service and shipped to the site in sealed, unopened plastic bags. Tubing not meeting these incoming quality standards is not to be used – it is to be returned to the supplier for credit.

Approved suppliers:
Swagelok series "ELD" [specify SC-1 cleaning] from Indianapolis Fluid Systems
Carten and Hills-McCanna may also be available, cleaning must be equivalent to Swagelok SC-1 or better

3.3. OTHER GASES

3.3.1. Specifications for Seamless Copper Tubing and Fittings

Please use the following chart for all applications of seamless copper tubing:

Application	**Material**	**Type**	**Specification(s)**
Buried Service	Copper	K	ANSI H23.1; ASTM B88
Supply Headers	Copper	K	ANSI H75; ASTM B88
Larger than 1"	Copper	K	ANSI H75; ASTM B88
Smaller than 1"	Copper	L or K	ANSI B75; ASTM B88
Fittings	Copper	Wrought	ANSI B16.22; ASTM B88 (s83% Cu)
Joints	Stay-Brite	Solder	ASTM B32.70
	Silver Solder	Brazing Rod	Silflos

3.3.2. Tube Fittings

For gases of less critical purity, swage-type compression fittings are acceptable.

Approved suppliers:
Swagelok fittings from Indianapolis Fluid Systems
A-Lok fittings from George Booth Company

3.3.3. Specifications for PVC (polyvinyl chloride) Pipe and Fittings

All materials must meet the ASTM specifications in the following table:

Item	Schedule	Type	ASTM Specification(s)
Pipe	40 or 80	N/A	D-1784, D-1785, D-2241
Fittings	40	Socket	D2466
	80	Socket	D2467
	80	Threaded	D2464
Solvent Cement	N/A	N/A	D2564
Thread Lubricant	N/A	N/A	3M Teflon Tape

3.4. LIQUID SUPPLY SYSTEMS

Ultra-Purity Teflon Piping Systems

Pipe, tubing, fittings, valves and other components must be precleaned, end-capped, and bagged under a nitrogen purge by the manufacturer prior to shipment to the site. End caps must be external, not requiring insertion into the pipe. Items not meeting these incoming quality standards are not to be used – it is to be returned to the supplier for credit. All components must be stored and handled in such a manner as to prevent damage and/or contamination.

Approved suppliers:
Flare-Tek Ultrapure PFA Tube Fittings, Entegris Fluid Handling Products
PureBond Weldable Pipe Products and Fittings, Entegris Fluid Handling Products
Fluoroline 4200 High Purity PFA Tubing, Entegris Fluid Handling Products
Integra Valves, Entegris Fluid Handling Products

Ultra-Purity PVDF Piping Systems

Pipe, fittings, valves and other components must be precleaned, end-capped, and bagged under a nitrogen purge by the manufacturer prior to shipment to the site. End caps must be external, not requiring insertion into the pipe. Items not meeting these incoming quality standards are not to be used – it is to be returned to the supplier for credit. All components must be stored and handled in such a manner as to prevent damage and/or contamination.

Approved suppliers:

SYGEF HP pipe, fittings, and valves, distributed by GF Plastic Systems, Inc.

High Purity PFA Tubing

High Purity PVDF Tubing

Polyflow Tubing

3.5. Process Vacuum Systems

Threaded SS piping or Grade 1 PVC pipe, Schedule 80, with socket-type fittings. PVC must be solvent welded with cement per ASTM D2564 with recommended primer.

3.6. Mechanical Vacuum Pump Systems

All vacuum pumps not part of a "pump package" must be mounted on a vacuum pump stand with integral Type C vibration isolators between the base assembly and the mounting assembly. A stainless steel drip pan must be mounted at the top of the mounting assembly (see illustration under Vibration Isolation). Flexible stainless steel bellows (minimum 6-inch) connectors must be used on both the inlet (equipment) and outlet (exhaust) side of the pump. The pump side of the bellows should float with the pump stand, and the equipment side of the bellows must be rigidly tied to the waffle slab. The exhaust side of the bellows may float with the exhaust system. **Please note that purchased vacuum pumping systems (such as "pump packages") must adhere to the concepts of this specification.** Of particular note, the equipment side of the bellows may not be tied to the pump support structure.

3.7. Drain Systems

3.7.1. Acid Waste Drain - Gravity

Flame-retardant polypropylene piping, Schedule 40, Type 1, conforming to ASTM D41-1. Fittings shall be flame-retardant polypropylene, designed to lock into a machined groove on mating pipe. Direct connection required. **Suggested supplier:** Labline.

3.7.2. Acid Waste Drain – Pressurized (pumped)

Grade 1 PVC pipe, schedule 80, with socket-type fittings per ASTM D-2467. Solvent weld with cement per ASTM D2564 with primer as recommended by manufacturer. Must be doubly contained with outer containment a minimum of Grade 1 PVC pipe, schedule 40 (clear PVC preferred).

3.8. Air-Handling Systems

3.9. Exhaust Systems

3.10. Electrical Systems

3.10.1. Conductors

No aluminum shall be used as an electrical conductor, and all connectors must be designed for copper conductors

3.10.2. Main Disconnect

Each machine not using a plug and cord shall have an external (or accessible, separately enclosed) and lockable main disconnect. The disconnect may be either fused or unfused, and shall have contact blades that are visibly disconnected in the open position. Though not preferred, a manufacturer-supplied circuit breaker is acceptable if separately enclosed and lockable. A rotary disconnect is not acceptable as a main disconnect.

3.10.3. Grounding

Grounding of electrical equipment shall follow the procedures as outlined in HDR 16450 Rev AD-3.

3.10.4. Twistlock Connectors

Any machine that requires more than 120 VAC, single phase, 30 amps, and may be plugged into a receptacle, shall use the following Hubbell Twistlock plugs and receptacles:

	120 VAC	**120 VAC/208 VAC**		**208 VAC**	
	1 Phase 2 Pole/3 Wire	**1 Phase** 3 Pole/4 Wire	**3 Phase** 4 Pole/5 Wire	**1 Phase** 2 Pole/3 Wire	**3 Phase** 3 Pole/4 Wire
	Plug /Recept NEMA Ref #	Plug /Recept NEMA Ref #	Plug /Recept NEMA Ref #	Plug /Recept NEMA Ref #	Plug /Recept NEMA Ref #
20 Amps		2411/2410A L14-20	2511/2510A L21-20	2321/2320A L6-20	2421/2420A L15-20
30 Amps	2611/2610A L5-30	2711/2710A L14-30	2811/2810A L21-30	2621/2620A L6-30	2721/2720A L15-30

3.10.5. Codes and Standards

The National Electrical Code (current edition) and Purdue University standards are to be used for details not covered by this guide.

3.11. WALL SYSTEM

The cleanroom wall system consists of 1/4” aluminum honeycomb panels (available from Plascore, Incorporated) attached to extruded aluminum self-supporting mullions.

3.12. VIBRATION ISOLATION

Vibration is a very significant concern to the Birck Nanotechnology Center cleanroom. It is critical that all vibration sources be isolated from the cleanroom slab, and that they have a method of dissipating the energy that is generated. In general, vibration sources are to be mounted to the subfab floor or the overhead Unistrut through vibration isolators. Connections to the cleanroom are through a vibration-isolating coupling (such as a bellows), with the downstream side of the coupling mounted firmly to the cleanroom slab. The following illustration of a vacuum pump isolation system is a good example of the implementation of this approach.

Five types of vibration isolators are used in the facility, designated A through E. For a guide to the individual hangers needed for a particular weight, refer to a manufacturer’s catalog. Following is a description of the types of vibration isolators:

Type A – Spring & Resilient Pad Hangers: Hangers consist of a steel spring and a neoprene-in-shear or fiberglass isolator placed in series and encased in a welded steel bracket. The spring element has a 20% overload capacity and the horizontal stiffness is a minimum of 1.0 times the vertical stiffness.

Approved Suppliers
Consolidated Kinetics Corporation, Model SFH-HD
Amber Booth Co., Model BSWR
Mason Industries Inc., Model PC30N

Type B – Resilient Pad Hangers: Hangers consist of a fiberglass or neoprene isolator encased in a welded steel bracket.

Approved Suppliers
Consolidated Kinetics Corporation, Model FH
Amber Booth Co., Model BRD
Mason Industries Inc., Model HD

Type C – Spring Mount, Open Springs: An adjustable, free-standing, open-spring mounting of specific static deflection with combination leveling bolt and equipment-fastening bolt. These hangers are the primary vibration-isolation devices used in the facility. They are used to support inertial bases on pumps, etc., and are used to isolate vacuum pumps from the support base (see illustration).

Approved Suppliers
Consolidated Kinetics Corporation, Model FDS
Amber Booth Co., Model SW
Mason Industries Inc., Model SLF

Type D – Spring Mount, Housed Springs: An adjustable, open-spring isolator having one or more coil springs attached to a top compression plate and a baseplate. They are used for cooling towers and heavy equipment only.

Approved Suppliers
Consolidated Kinetics Corporation, Model FLS
Amber Booth Co., Model CT
Mason Industries Inc., Model SLR

Type E – Isolation Pads: Isolators are compressed molded Fiberglass noise and vibration isolation pads, individually coated with a flexible, moisture-impervious, elastomeric membrane. These are used between the chillers and their housekeeping pad in the Central Plant.

Approved Suppliers
Consolidated Kinetics Corporation, Model KIP

To avoid vibration being transmitted to the cleanroom floor, any machinery (e.g., vacuum pumps, chillers, exhaust blowers) located on the subfab floor or on platforms attached to the subfab floor shall be fed electrically through flexible Sealtite conduit. The flexible conduit shall run between the machine and rigid conduit that is attached to the cleanroom floor or the subfab columns. The distance of each run of flexible conduit must be minimized, and must consider vibration isolation. In the subfab, this is generally accomplished through a loop in the flex; in the cleanroom a 90 is generally used. Also, no electrical device on the subfab floor shall be connected to the electrical busway without using a piece of flexible conduit.

3.13. SAFETY EQUIPMENT AND SYSTEMS

3.13.1. Safety Shower/Eyewash Stations

Integral safety showers and eyewash stations are required in locations where hazardous liquids are in use. The safety shower must be close enough to the location of chemical use and free of impediments such that it can be reached by a non-seeing person (such as someone who has chemicals splashed in their eyes).

Safety shower/eyewash stations must be constructed of non-contaminating materials – all-plastic systems are highly recommended.

Provision must be made for personal privacy while disrobing in a safety shower. Opaque walls and an opaque safety blanket (non-contaminating material) can be used to accomplish this.

Locations must be chosen such that an electrical hazard is not created by the discharge of the safety shower. Any electrical outlets in proximity to the shower must be protected by ground-fault circuit interruption.

3.13.2. Hazardous Gas Monitoring

The hazardous gas monitoring system is to be designed such that inputs are located in the most likely area to collect fugitive emissions from the distribution system and points of use. This generally includes location within the exhaust duct immediately upstream from where an emission is most likely to occur. The alarm threshold is set to 50% of the TLV for toxic gases and 50% of the LEL for flammable gases.

Environmental monitors are to be located immediately downstream of the most likely fugitive source, taking into account the specific gravity of the gas. For example, chlorine monitors are to be located below the most likely source because of the high specific gravity of chlorine.

3.13.3. Fire Suppression Systems

Equipment made of combustible materials ***or*** containing combustible chemicals must be equipped with fire suppression systems, either approved gaseous-agent systems or fire sprinklers. These systems must be designed and installed such that they provide suitable fire protection to the equipment, contribute no contamination to the equipment, and allow proper airflow to the product-wafer areas. They must be constructed of materials that are compatible with the chemicals in use in the equipment.

CAUTION: The use of metallic piping and threaded connections in wet stations is discouraged. If metallic piping is used, it must be stainless steel and must be protected from corrosion – painting with epoxy enamel is recommended. Pipe threads trap contaminants and by their nature provide particles during the connection process. Their use is discouraged, but if used must be painted with epoxy enamel following the "making" and leak-testing of the joint.

3.13.4. Fire Extinguishers

Fire extinguishers must be located at strategic locations throughout the cleanroom and subfab. See the REM department for appropriate locations and for the appropriate extinguishing agent. Dry powder extinguishers are not appropriate for the Birck Nanotechnology Center.

Fire extinguishers must be noncontaminating, and all painted surfaces must be intact and non-flaking. Extinguishers must not be located in the airflow path leading to product-wafer areas – location in the chase is generally preferred.

DANGER: Some gaseous chemicals used in the Birck Nanotechnology Center are not compatible with certain extinguishing systems. For example, diborane is not compatible with Halon and dichlorosilane is not compatible with water.

4. INSTALLATION PROCEDURES

4.1. SAFETY EQUIPMENT AND PROCEDURES

It is critical that the appropriate safety equipment is available during the equipment-installation process. If areas where equipment is being installed are isolated from the cleanroom, those isolated areas must be provided with readily accessible safety equipment, as appropriate (See MSDS's for materials present). Typical equipment that is required during equipment installation might be self-contained breathing apparatus (SCBA) **in pairs**, safety showers, personal protective equipment for acids, etc.

The equipment owner must be involved in all situations involving hazardous materials hookup and modification, as must the REM department. They must ensure that the knowledge, equipment, and materials necessary to maintain safety are present. The ultimate responsibility for safety lies with the individual performing the task, and that person must follow the procedures and use the safety equipment and materials provided to ensure their safety while performing these tasks.

Special care must be taken if connections are made to lines that have ever been exposed to hazardous materials. This applies to tie-ins to existing lines or to the reuse or modification of formerly used lines. For all such work, the buddy system must be used for the initial penetration of the line.

For liquid or solid chemicals, these precautions also involve the use of personal protective equipment (i.e., gloves, face shield, protective jumpsuit) on the initial cut into the line. After inspection of the cut, if any residues of the hazardous chemicals are present, the personal protective equipment is required for the rest of the tear-out.

For gaseous chemicals, breathing apparatus is required for both people, either an airline cart or a self-contained breathing apparatus. After penetration of the line, the air must be tested for toxic residues prior to removing the breathing apparatus.

It is critical that equipment lockout practices be followed. Please practice University lockout procedures on all equipment-installation operations involving active energy sources.

4.2. EQUIPMENT-INSTALLATION IN A CLEANROOM

Accomplishing the cleanliness goals of the facility and the utilities supplied within that facility require special precautions outside of the scope of normal equipment installation practices. Even before cleanroom protocols are enforced, an attitude of cleanliness is necessary.

Each tradesperson and staff member is responsible for keeping his/her work area clean and safe, and for leaving the area cleanable at the end of the shift. Leaving the area safe includes such practices as replacing covers on electrical boxes. Leaving the area cleanable involves removable of extra materials and organization of materials that are being used.

4.2.1. Periodic Housekeeping

In addition to the normal cleanup performed by the trades, all equipment-installation areas within the cleanroom and chases must be cleaned by housekeeping at least once per shift (that installation is taking place). In areas that are very critical, and in areas where a great deal of contamination is created, this frequency of cleaning may need to be increased significantly.

In all cases, the area must be left clean at the end of the equipment-installation day. This requires that the trades leave the area cleanable, and that housekeeping performs an end-of-day cleaning.

The primary cleaning method is vacuuming, using a cleanroom vacuum. This often must be coupled with more aggressive cleaning, such as mopping or scrubbing, and those must always be followed by vacuuming a second time. Neither vacuuming step should be skipped!

During these daily cleanings, the housekeeping staff should note any cleanability problems, such as piping locations that would inhibit cleaning after the installation is completed. This information must be communicated to the installation supervisor, who can alert the trades to the problem.

4.2.2. Cleaning of Tools

Special precautions must be taken in bringing tools into the cleanroom. Whenever practical, tools should be cleaned, brought into the cleanroom, and left in the cleanroom for the duration of the project. If this cannot be accomplished, then the tools must be cleaned on ***each*** entry into the cleanroom.

Tools taken into the cleanroom must be inspected and precleaned as necessary. No rust or other corrosion should be present, and grease and gross soiling of the tools must be removed prior to the cleaning process.

Once inspected and precleaned, tools must be wiped with an Anticon 100 wiper moistened with isopropyl alcohol. Cleanroom gloves must be worn during the cleaning operation, and the tool must not be touched with ungloved hands after it has been cleaned.

4.3. GAS CABINETS AND VALVE-MANIFOLD BOXES (VMBS)

Gas cabinets, located in a gas bunker, are required for all hazardous cylinder gases. They are recommended, but not required, for nonhazardous gases. If not installed in a gas cabinet, they must be securely mounted to a gas rack.

They are to contain a purge (typically nitrogen) cylinder and either one or more active cylinders. If multiple active cylinders are to be contained in the same gas cabinet, they must be chemically compatible and of like hazard (see Gas Hazard Chart). Note that in certain instances, carbon dioxide is used as a purge gas. In rare instances argon, helium, and other inert gases do not use purge cylinders.

Note that purge cylinders perform an important role in preventing contamination – especially moisture – in addition to their role in safety. IN NO CASE MAY THE PURGE LINES FOR A CYLINDER BE CONNECTED TO THE HOUSE NITROGEN SYSTEM! They must be connected to a dedicated purge cylinder. Purge gases must be of an equivalent (or better) purity level than the process gas to maintain contamination control.

Those gases that react with Halon fire suppression agent must be clearly labeled on the front of the cabinet. ***Carbon dioxide extinguishers must be located near any gas cabinets and equipment where dichlorosilane and nitrogen trifluoride are used. Water extinguishers must be located near any gas cabinets and equipment where diborane is used. Halon reacts unfavorably with these gases.***

All gas cabinets that contain a hazardous (non-inert) gas must have a sprinkler head plumbed in the cabinet. A sprinkler head is recommended for all cabinets.

All gas cabinets containing hazardous gases must have a normally-closed emergency shutoff valve connected to the Emergency Shutoff System.

4.3.1. Exhaust Requirements

Gas cabinets containing toxic, flammable, corrosive, or oxidizing gases must be ducted to an exhaust system, according to the Gas Hazard Chart. The minimum exhaust requirements must be the manufacturer's specifications for that cabinet, or in the absence of such requirements must maintain a minimum face velocity of 150 fpm at the open window and provide control of a release at the maximum leak rate as rated for the restricted flow orifice (RFO) at the associated cylinder pressure.

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The bonnet vent line and the purge line may be connected to the cabinet exhaust duct, but must be at least 8 feet from the gas cabinet at their connection point. This is to minimize the possibility of backstreaming from these lines into the cabinet.

4.3.2. Manual vs. Automatic Gas Cabinets

Manual gas cabinets are for use with non-hazardous gases only. Gases with a hazard rating of "3" or "4" require an automatic gas cabinet.

4.3.3. Gas Cabinet Checklist

Before any gas cabinets are brought on line, the Gas Cabinet Checklist must be attached to the door and signed by the appropriate people during each step of the operation. The gas cylinder is not to be installed until all steps prior to Step #22 on the checklist has been completed. The checklist in this manual may be copied for this purpose.

4.3.4. Gas Cabinet Labels

All gas cabinets must be labeled with the following information:

Name of Gas	Chemical Formula	Gas Cabinet Number
Equipment or VMB supplied by the cabinet		NFPA Diamond

The information on the label must match the nomenclature of the Gas Hazard Chart.

If the proper labels are not available prior to the time that the gas cabinet is needed, a temporary label may be attached to the door of the cabinet. This temporary label must contain all of the information noted above, as well as the date the label is affixed to the cabinet. Temporary labels must be replaced with permanent labels no later than 14 days following the date the temporary label is put in place.

4.3.5. New Gases

If a new gas (i.e., a gas currently not in use in the Birck facility) is to be used, several steps must be taken in the implementation of this gas. First, approval for the use of the gas must be received from both REM and the Building Safety Committee. As part of that process, the hazards of the gas must be reviewed and the need for monitoring by the Toxic Gas Monitoring System must be evaluated. If approved, the gas must then be added to the Chemical Inventory for that room.

New gases requiring monitoring must be provided with **both** fixed monitors in key locations attached to the TGM System and a portable monitoring capability (such as Draeger Tubes).

4.3.6. Reuse of Gas Cabinets

A gas cabinet is being reused when either 1) it is relocated and put in service with the same process gas, or 2) the process gas used in the cabinet is changed, whether or not the cabinet remains in its present location. To maintain process integrity and life-safety, certain special conditions must be met for the reuse of a gas cabinet.

It is strongly recommended that the only reuse of a gas cabinet for an ultra-purity gas involve the replacement of all the components in the gas stream with new components. If the components were used for a hazardous gas, then proper disposal of the components is necessary. Thus the reuse would be of the cabinet and the electronics, not the piping.

When opening a line that has been exposed to hazardous gases, appropriate personal protective equipment (e.g., SCBA) must be worn.

Same process gas

Gas cabinets that are relocated for use with the same process gas must follow the same procedure and requirements as the purchase of a new gas cabinet. If the gas cabinet was used for a highly corrosive gas, such as HCl, it is not recommended that it be reused. If this recommendation is not followed, the components must be inspected to insure that corrosion is not present, and the piping system must be purged with heated nitrogen to ensure that all moisture has been removed from the system. Heated nitrogen can be obtained by the rental of a heat exchanger rated for 400-degree nitrogen.

Different process gas

Gas cabinets that are to be used for different process gases require extra precautions. In addition to all of the procedures and requirements for a newly purchased cabinet, the following requirements must be met.

- The new process gas must be compatible (see chart) with the previously used gas. The alternative to this is to replace all of the components in the gas stream, and reuse only the electronics and the cabinet.
- If the new gas is compatible with the old gas and the existing components are to be reused, they are to be inspected to verity that they are in a suitable condition for reuse.
- If the gas cabinet is remaining in the same location, it is critical that the modifications be made, if necessary, to ensure that the cabinet is connected to the proper exhaust system.
- The labeling of the gas cabinet and lines must be changed to match the labeling for the new process gas.

Note that all other requirements related to new gas cabinets apply to the reuse of gas cabinets.

4.4. ULTRA-HIGH-PURITY GASES

4.4.1. General Information – All Steel and Copper Piping

Routing of distribution piping

All distribution systems are to be routed such that the area beneath the chase is kept clear of manifold lines. Whenever practical, the only lines located beneath the chase should be the lines that are penetrating the floor at that location.

Valve installation and location

Install valves with stems upright or horizontal, not inverted. Install gate valves for shutoff and isolation of the service liberally. Use to isolate equipment, portions of the system, and vertical risers to the chase.

Pipe hangers and supports

Horizontal steel and copper piping must be supported at each change in direction, at the ends of branches, at the top and base of riser pipes and drops, and wherever necessary to prevent sag, bending, and vibration. The following table serves as a guideline:

Nominal Pipe Size	Maximum Distance Between Supports	Hanger Rod Diameter	Vibration Isolator Type
1/8”	6’	$^{3}/_{8}$”	A or B
¼”	6’	$^{3}/_{8}$”	A or B
3/8”	6’	$^{3}/_{8}$”	A or B
½”	6’	$^{3}/_{8}$”	A or B
¾” – 1 ½”	6’	$^{3}/_{8}$”	A or B
2 – 2 ½”	10’	$^{3}/_{8}$”	A or B
3” – 4”	12’	$^{5}/_{8}$”	A or B
6” – 12”	12’	$^{7}/_{8}$”	A or B

Where several pipes can be installed in parallel and at the same elevation, trapeze hangers are to be used. In this case, use the appropriate A or B vibration isolator, according to the weight to be supported. Where practical, support riser piping independently of connected horizontal piping.

4.4.2. Material Inspection Procedures

After material has been unloaded and logged in on the master-receiving log, Purdue personnel will visually inspect all material packaging for any damage. If any damage to the outside bag is found, that piece of material will be tagged to be part of the 10% inspection.

Heat numbers of the material supplied are to be verified that they correspond to the mill test reports submitted by the suppliers. The chemical analysis on mill test reports will be checked to insure they are within ASME B31.3 standards. Close attention will be paid to the sulfur content to insure it falls within the 0.005 to 0.015 percent limitation.

Move 10% or a minimum of two from each material lot into subassembly cleanroom. A detailed inspection of the material will be performed. All of the materials inspected will be checked for conformance to the manufacture's specifications and the applicable ASTM codes. Visually inspect outside diameter of material for dents, flattened areas, scratches and a general smooth exterior surface. Visually inspect inside diameter for surface imperfections such as pits, scratches, orange peel, stains, and residues. Surface should be highly polished and mirror-like with a high degree of reflectivity.

Electropolished material will have a 10 R_A AVERAGE surface roughness. Analysis will be on the surface areas that are accessible with a stylist profilometer. Material wall thickness should be checked in two places 180-degrees opposite each other and verified against the manufacturer's specifications. Material ovality will be checked by measuring the outside diameter in two places 90 degrees apart and verified against the manufacturer's specifications.

Upon completion of the lot inspection, each component will be individually heat-sealed in two polyethylene bags with a positive nitrogen or argon atmosphere. Mark the material that has met all inspection criteria as "Accepted" along with the date and lot number. The accepted material will then be stored until it is used. Material that does not meet specification criteria will be tagged as "rejected" along with the date and lot number. When there is rejected material in the first 10% of a lot, then a second 10% of the same lot will be inspected. If any more material is rejected from the same lot, then 100% of the lot will be inspected. The Construction Supervisor will be notified of any rejected material at the time of rejection. All rejected material will be logged and returned to the supplier for replacement or credit.

As part of an overall check of material quality, one test per heat number and size of tubing and valves will be subjected to Particulate Analysis. Additionally, acceptable particle count will be based on the equipment owner's specifications.

4.4.3. General Fabrication Procedures

All cutting and cleaning for high-purity application will take place in the subassembly cleanroom.

All stainless steel tubing and components installed in high purity systems shall be welded using an automatic orbital tube-welding machine, operated by a qualified welder.

The argon gas used for welding will be from a cryogenic source, or by a source approved by the lab staff, with maximum impurities by volume of:

Oxygen = 10 ppb
Moisture = 10 ppb
Total Hydrocarbons = 10 ppb

Prefabricated assemblies will be installed in the field as soon as possible after completion.

Prefabricated assemblies greater than 6 feet in length will be transported to the installation location by two people. Assemblies must be capped and double bagged on all ends so as not to cause damage to them, and contaminate the assembly.

4.4.4. Transferring Tubing to Fabrication Area

As a length of tubing is being taken into the Fabrication Area, remove the outer plastic sleeves and visually inspect tube for any damage (bent, flattened, discolored, deeply scratched, etc.).

Use an Anticon Gold wiper, moistened with deionized water, to wipe off the exterior surface as it enters the Fabrication Area, taking care not to disturb the plastic end caps.

When any length of tubing is visually damaged, separate it from the rest of the lot and notify the Construction supervisor.

4.4.5. Tubing Preparation

To mark the tubing to the needed cut length for fabrication use a sharpie marker to mark the location. Wipe the scribed area with an Anticon Gold wiper, moistened with deionized water and/or IPA, until clean.

Attach a 0.003 micron filtered argon purge to one end of the tube to be cut and attach a purge fitting with a restrictor to the other end. Purge flow rate should be approximately 30 scfh.

Tubing shall be cut using clean tubing cutters designated for stainless steel use only. A hacksaw or similar type of cutting tools shall not be used. During cutting, take care not to swage the ends of the tube by exerting too much pressure on the cutters. When the cut is complete, cover the ends of the drop piece with Polyamide Nylon #6 and plastic caps and return to the designated rack or storage area.

Label cut length with dimension and drawing number. Turn purge flow rates down to 10-20 scfh and insert a deionized-water-moistened Anticon Gold pig into the end to be squared. A pig should be used on all sizes ½" and larger, and be at least 1.5 times the diameter of the tube.

A Tri-Tool Corporation tubing prep tool or equal will be used to square tube ends for orbital welding preparation. A clean Swagelok deburring tool, designated for stainless steel use only, will be used to deburr the tube ends after squaring.

Install the tube end into the clamp assembly of the prep tool and tighten the clamp securely. Check alignment and condition of cutting blade. Start the squaring operation, being extremely careful not to allow material shavings to enter the tube and scratch the polished surface.

After the tube end is squared, lightly deburr the I.D. and O.D., taking care to remove only burrs and not to remove an excessive amount of material. Once the end preparation is completed, remove the pig from the tube. Be very careful not to scratch or touch the inside of the tube.

Reverse the purge and repeat squaring and deburring procedures on the other end. Factory tube ends will be checked and then squared and deburred if required.

Tube end preparation is now complete. The tube lengths can now be cleaned or have the ends sealed with Polyamide Nylon #6 and plastic caps and set aside for final cleaning later.

4.4.6. Tube Cleaning Procedures

All high purity stainless steel tubing that has been cut to size will be re-cleaned before fabrication following the procedures outlined in this section.

Form a snug-fitting Anticon Gold wiper with a new clean wiper (Use pigs provided for 1/2" and larger tubing.) Drape at leas two layers of new clean wiper over pig. Note: During this and all other cleaning procedures, use Anticon Gold wipers only once

Propel clean wiper through tube with purified and filtered argon or nitrogen. Catch the clean wiper at the opposite end of the tube with a basket.

Inspect all clean wipers under a magnifier. If any clean wipers are discolored or have any particle matter, remove the argon or nitrogen and replace the plastic end caps on the tube. Place clean wiper in a plastic bag. Attach the plastic bag to the tube with a YELLOW TAG and place the tube aside for inspection.

If the clean wiper shows no sign of discoloration or particle matter, immediately place a piece of Mylar over the open ends and place a cap over the Mylar. Tape cap on the tube. Place polyamide bag over the cap, tape approximately 1 inch from the end of the tube. Tape must be cleanroom tape.

Cover the Polyamide bag with another bag and tape approximately 2 inches from the end of the tube.

Place the packaged tube in the clean component storage area awaiting call from field crew.

4.4.7. Fitting Cleaning Procedures

Unbag the fitting and visually inspect the I.D. of each fitting for contamination. Only fittings that show signs of contamination will be required to be re-cleaned

To clean fittings, blow down fitting with purified and filtered argon or nitrogen at minimum of 100 scfh for 1 minute.

Visually inspect the fitting for any foreign material. If any contamination that cannot be removed is visually apparent, reject the fittings and notify the appropriate member of the lab staff.

Once the fitting has passed the visual inspection, seal the ends using a new layer of Polyamide Nylon #6 under an external-fit plastic cap.

Seal the fitting in a polyethylene bag while under an Argon purge. Double seal the fitting in a second bag. Label the fitting “Cleaned” with the date and initials of the person who performed the cleaning operation.

4.4.8. Purging Procedures

All high purity stainless steel systems shall be continuously purged with argon that meets the specification outlined in paragraph 4.4.3. Only electropolished stainless steel tubing with high purity mechanical connections shall be utilized for internal purge. No Poly, Teflon or PFA tubing shall be used to connect the internal purge to the piping systems.

During welding, the tube system shall be continuously purged with certified 0.003 micron filtered argon and allowed to escape to atmosphere through a purge restrictor. The welding head of the orbital welding machine will have a continuous purge.

For each purge restrictor, there shall be a minimum flow of 10 to 15 scfh of argon.

A flowing purge shall be maintained at all times the system is opened to the atmosphere. Anywhere the line is open to atmosphere and left unattended it will need to be covered with a bag. Puncture a small hole in the bag to allow argon to escape, then seal to the O.D. of the tube with tape. Always leave the purge supply valve opened slightly so that if a leak developed during an inactive period the system will not be exposed.

PLAN AHEAD - Be sure the supply of purge gas is adequate for the work planned. Provide necessary isolation valves in a manifold to connect and disconnect cryogenic sources without any interruptions in purge service. Additional valve for analytical and process instrumentation is also required at the gas manifold.

4.4.9. Welding Procedures

All stainless steel lines for ultra-purity systems shall be welded using an Arc Machine automatic orbital tube welder operated by a certified welder.

A weld perimeter program and coupon for each size of tubing to be used on the project shall be developed. All welders will utilize the approved weld programs.

The orbital welder shall dial in the qualified weld parameters and make the necessary adjustments to produce an acceptable opening (“in”) coupon. Coupons will be required before and after changes in tungsten, power source, tube size, 20° change in temperature or at the request of the Construction Supervisor. Coupon purge will be from same source as the system being welded.

After an orbital welder produces an acceptable butt weld coupon, s/he will inspect it.

The welder will inspect it for insufficient or excessive penetration, discoloration, alignment, workmanship, and cleanliness. Once the coupon has been accepted, it will be properly tagged with orbital welder’s I.D.

number, date, time of day, and assigned coupon number. The welder shall then be able to start making production welds.

Once the welder is ready to start production welds, he will clean his gloves or replace them if they are damaged.

To start welding, take a filtered argon purge and turn on flow to approximately 30 scfh. Install a clean purge adapter to the filter that fits the size of tubing to be welded.

Turn the weld head purge on, using the manual purge button on the welding machine, and adjust the flow to manufacture's recommended flow for the weld head being used.

Attach the purge adapter to one end of the tube or fitting to be welded. Remove the other plastic cap and allow argon to flow through.

Quickly, visually inspect the end for any damage or contamination. If none is apparent, attach a magnahelic assembly. Unseal the tube or fitting end to be welded and insert into other end of magnahelic assembly. Install the proper size purge restrictor at the other end. Adjust the flow rate down to the desired pressure for welding of the size of material being worked. Allow time for line to adjust to new flow rate.

After proper flow and ID pressure are set, remove the magnahelic assembly and quickly insert tube ends into the weld head. Align the end of the tubes or fittings to the tungsten, clamp down the weld head collets, and be sure to support the weight of the tube or component so as not to put undue strain on the weld head collets.

After allowing sufficient time to remove oxygen out of the tubing, proceed in starting the weld program.

Each welder shall identify each of his weld joints on a weld-tracking log. Each welder shall identify each of his weld joints by marking his regularly assigned identification number, weld number, (as found on the isometric drawing), and the date with a fine point permanent marker on the tube immediately after the weld is made.

The welder will visually inspect the weld and if it is acceptable, sign it off on the weld tracking log, If the weld is not acceptable it will be cut out and remade until it is within the outlined specifications. It is important that the welder keep up to date with his weld-tracking log that is required for each isometric drawing. All rejected welds will be logged with a description as to why they were rejected.

After the weld is completed and no more work is to be performed, place a polyethylene bag over the purge restrictor, taping the bag to the tube. Puncture a small hole in the bottom of the bag to allow argon to escape. Always leave the purge valve opened so that a constant purge will always be present.

4.4.10. Weld Specifications:

Alignment:	A maximum misalignment of 10% of wall thickness will be allowed in the fit-up of the butt weld joints
O.D. Concavity	Concavity is not to exceed 10% of the wall thickness.
O.D. Convexity	Convexity is not to exceed 10% of the wall thickness.
O.D. Visual:	The weld shall be free of any indications of porosity cratering, or embedded foreign materials.
Bead Width	Outside bead width not to exceed 3X wall thickness Inside bead width not to exceed 2.5X wall thickness and be no less than one wall thickness.
Discoloration	***No discoloration or oxidation of the weld will be allowed.***

An orbital welder will make a Bead On Tube (BOT) after 4 hours, and a closing ("out") coupon at the end of the day to verify welding machine performance before changes in tungsten, power source, or tube size. The Construction Supervisor will inspect and log all weld coupons.

The closing coupon will be evaluated for complete penetration, and discoloration. If any "out" coupons are rejected, the Construction Supervisor will determine if a second attempt without changing any weld parameters will be made. If coupon is still unacceptable, then the last weld made will be visually inspected. The weld will have to be cut out if not accessible. Inspections will continue in reverse order, until an acceptable weld is found.

Only one (1) welding pass will be allowed on all welds with out the prior approval of the Construction supervisor.

4.4.11. Orbital Welder Qualification Procedure

Interview

Welders will be interviewed by the appropriate lab staff member(s) to determine level of training and experience in high purity orbital butt fusion welding.

Pre-test Qualification Procedure Outline

Before beginning the qualification test, the welder will be provided the following outline of test areas that will be evaluated. Questions will be answered at this time.

Clean Welding Protocol

Proper high purity techniques in cutting, facing and re-cleaning of the weld coupons.

Proper high purity techniques in the handling of pre-cleaned stainless steel tubing.

Set-up and use of the high purity purge.

The ability to establish weld programs and evaluate necessity of program changes to produce acceptable quality welds.

Equipment for Qualifying Personnel

Arc Machine Orbital Welding Machine

Arc Machine Orbital Welding Heads

Tri Tool Weld Prep Tool

Argon

Purge Adapters

Purge Filters

Orbital Welder Evaluation Criteria

Witness the calibration of the weld heads.

Have the Welder develop a base line program for a particular size and wall thickness of tube from scratch.

Observe proper high purity techniques in cutting & facing of coupons.

Observe proper high purity techniques in the set-up of the purge system.

Observe proper set-up of the weld machine and weld heads. If a welder is going to use an ARC Machines 9-500 Weld head, he will have to qualify using it.

Monitor the Welder's ability to make a weld, then evaluate it and make the necessary adjustment to the machine. They will continue this process until he produces an acceptable weld coupon. We will allow one

(1) bead on tube and eight (8) butt welds. If they cannot accomplish an acceptable coupon within two (2) hours, they will be stopped.

All the coupons will be marked with the welder's name, ID number, date and sequence number. This will be bagged and stored by QA/QC.

If the welder passes the evaluation he/she will then proceed with the Welder Certification Process.

Welder Certification

Weld Coupon will be cut and inspected for: insufficient penetration, excessive penetration, proper deburring techniques, oxidation, cleanliness, amount of ID and OD discoloration, and workmanship, using the parameters described in section 3.7.16

Each welder will produce a certification coupon for each wall thickness of tubing he is to weld on. A chart will be on file listing all welders and the wall thickness they have certified.

Owner may witness the entire certification procedure.

The Construction Supervisor will fill out a Welder Certification with a weld parameter sheet showing the machine setting used for the test. These will be retained by the Construction Supervisor.

A welder who is rejected will not be allowed to re-qualify until after he has demonstrated additional training or experience through formal programs such as Arc Machines or through apprentice programs available to fitters supporting the qualified welders. Only one additional attempt at re-qualification will be allowed. This re-qualification attempt will be allowed only after 6 weeks from his first attempt at certification.

Any welder who has previously certified under this qualification procedure and has remained active as an orbital welder within the past 3 months will not be required to re-certify.

TIG Welding

For joints over one inch, TIG welding is used. The same purging requirements apply, and similar procedures to the orbital welding are to be used.

4.4.12. Subassembly Fabrication Area (SFA) Protocol

Materials and Equipment

IPA and Deionized Water

Anticon Gold Cleanroom wipers

Latex gloves

Vacuum cleaner (HEPA cleanroom vac or vac located outside room with hose into room)

Cleanroom garments (booties, hood, smocks, facial covers)

Cleaning Procedure

On a weekly basis the SFA will be cleaned above the normal daily housekeeping in accordance with the procedures outline below.

Vacuum floor, work surfaces, carts, etc.

Wipe down all interior wall surfaces, tables, storage racks, carts, pass through chambers, tools, etc. with a mixture of 95% deionized water and 5% IPA

Mop floor with a mixture of 95% deionized water and 5% IPA

Housekeeping

Do not take any particle generating materials into clean areas.

If you must take paper into the cleanroom, use cleanroom paper or enclose the paper in a plastic cover so as not to contaminate the cleanroom.

Only approved ballpoint pens will be used in the cleanroom for writing.

Always pick up trash after yourself throughout the day. Never leave trash lying on the workbench or floor.

Keep all equipment, tools, etc. below bench level.

Never leave cleaning or purge lines open to atmosphere. Always leave a slight purge (approx. 5 scfh) on them or cap off the end. When not in use always cap off and bag to conserve gas and to prevent contamination.

Never tear or cut cleanroom wipers.

4.4.13. SYSTEM TESTING

PRESSURE TESTING

The installation supervisor and appropriate lab staff member(s) will walk the completed system and submit for pressure test.

A pressure test will be performed according to Site Service Index 15059

HELIUM LEAK TEST

An inboard helium leak test will be performed by evacuating the system, and pulling a vacuum to 1×10^{-9}.

After the leak test is performed the system will be back-filled with argon.

PARTICLE TEST

A purge will be initiated and a flow rate of 20 fps will be set.

A particle test will be performed The specification allows for less than 5 particles per cubic foot, 0.01 micron or larger.

MOISTURE / OXYGEN TEST

A moisture and oxygen test will be performed with an acceptable level of 10 ppb above background levels of test media, and less than 100 ppb absolute.

When moisture and oxygen test is completed, the system will be tagged to show system has been certified for Purity and Integrity.

When testing is completed system will be turned over for hook-up.

When a fitting is tightened, a drop of Torque Seal will be applied to the fitting to safeguard against loosening of the fitting (if seal is broken there is a chance of system contamination).

4.5. *LIQUID SUPPLY SYSTEMS*

4.5.1. Ultra Purity PVDF Systems

Tube cutting procedure

Remove end caps only long enough to scribe accurate measurement and replace cap. Allow + 1/8" per end to be fused for facing as required.

Clean area to be cut – at least 2 inches on both sides of the scribe mark – with a clean Anticon 100 wiper dampened with semiconductor-grade IPA (2-Propanol). Clean well enough to remove any discoloration or markings.

Cut with a wheel-type tubing cutter **only**. Care must be taken not to deform the ends of the tube. Inspect tube for debris and quality, and cap or bag tube ends. Mark cut length, lot number, service, and ISO number on label provided and affix the label to the center of the cut length. Cap open end of unneeded cut length and label with lot number.

Cut Outs

Use the following procedure for the removal of components, sections, or fused joints from existing installations or sub-assemblies. These procedures are in addition to the good judgement of the fuser or pipefitter and to all rules, regulations, and procedures applicable to high-purity PVDF piping systems.

1. Make the required cut using a sharp wheel-type cutter. Care must be taken not to deform the pipe ends.
2. Insert a clean Anticon 100 wiper into the newly cut ends just far enough as to not interfere with the facer. Square pipe ends as appropriate.
3. Use a clean Anticon 100 wiper to brush away excess chips or savings. Carefully remove the inserted wipers, bringing any chips or shavings with them. Cap or re-fuse the joint.

Heat-Fuser Qualification Procedure

The heat-fuser must be familiar with the setup and proper preparation of fusion equipment, including all adjustable items, specifically:

1. Confirmation of correct clean power source (voltage and phase requirements) for the type of machine being used.
2. Checking for proper height and side-to-side alignment for heater bushings, facing tools, peeling tools, etc., and pipe/fitting contact.
3. Visually checking for proper alignment.
4. Proper setup of all applicable components for each type of fusion, including pipe clamps, penetration stops, supports, inserts, heater bushings, overlap distances, and all related items for the type of fusion machine being used.
5. The setup of printers on heat-fusers equipped with printout capabilities.
6. The selection of fusion parameters, including material selection, date/time notation, set point adjustments, etc., for fusion machines quipped with microprocessor menus.

Preparation of Fusion Coupon Samples

Upon request and according to installation procedures, each heat-fuser must be able to produce any size fusion coupons as follows:

1. A socket-fusion joint displaying proper material preparation, bead formation – internal and external – socket penetration with flush-out area and with an absence of voids in the socket area.

2. An infrared (IR) fusion joint showing proper preparation, bead formation, and alignment.

A rejected fusion joint might contain a cold fusion or a void in an of the fusion areas, collapsed ID in socket fusion, and too small or two large an IR fusion bead.

Fusion Samples

Visual inspection of the following fusion joints

Sizes to include all sizes used in the current project.

IR Fusion: Pipe to pipe, pipe to fitting, fitting to fitting.

Socket Fusion: Pipe to pipe using couplings, pipe to fitting, fitting to fitting

Hydrostatic testing of a spool piece

Spool piece shall contain a minimum of three fusion joints, constructed with flange adapters (with backing rings) on each end, and shall be constructed for 2" and 4" socked fusion and 2" and 6" IR fusion. These sizes may be changed based on the sizes in use on the job.

Verification of the fuser's ability to set up the machine

Set up machine for a given pipe size, including heater head of bushings, printer, software manus, inserts, supports, and clamps. Provide verbal explanation and purpose of any part of the fusion system and/or heat-fusion process, properly prepare pipe or fittings for fusion, identify key elements of an acceptable joint versus an unacceptable joint.

Heat-Fusion Procedure

Confirm that the fusion equipment is in clean, good working order with no missing parts and has all the necessary tools used for adjustments and component changes. Confirm that the fusion equipment is connected to a proper and reliable (dedicated, if practical) power source that will not be subjected to power fluctuations, surges, or variations. The fusion systems have the following power requirements:

System	Voltage	Phase	Power
IR-225	220	3	3 kW
IR-63 w/o converter	220	1	1 kW
IR-63 with converter	110	1	1 kW
SG-160	115	1	3 kW
Bielomatic	115	1	3 kW

All voltages are ±10 volts maximum

Installers are to wear proper cleanroom gloves and attire for the cleanroom where the fusion is conducted.

Prepare fusion coupons at the start of the shift, at any change in the power supply, heater heads, or change in fusion system, at any indication of a defective fusion joint, at a change in fusion temperature of 20° F or greater, and at any change in pipe size, wall thickness, an batch/lot number. Use the procedure that follows to make these coupons.

Once the coupon is approved, proceed with the heat-fusion using the same procedure.

IR Fusion Procedure

1. Select coupon material of suitable length to be fully supported and confirm correct pipe clamps, inserts, and machine operation.

2. Select fusion parameters and data from the selection menu display for the correct date, time, material, pipe size, and wall thickness. Adjust the overall distance (±0.5 mm) to correspond with the programmed set point for the pipe data selected.

3. Position the cut pipe or fittings in the machine clamps, checking that the samples are properly aligned and level. Confirm that the correct pipe data are on the menu. The display should read *facing* screen.

4. Install the pipe stop (plastic block for IR 63, metal "U" fitting for IR 225) and push the sliding bed until it is fully closed on the pipe stop. Push the pipe or fittings against pipe stop and tighten clamping levers.
5. Remove the pipe stop and check the alignment. Position the facing tool and the face fitting until the stops are contacted. Remove the facing tool and check the facing distance until it is within tolerance. Hold three seconds until the machine registers *OK*.
6. Cap all pipe and fitting ends and confirm by pushing the *enter* key.
7. Using an Anticon 100 cleanroom wiper, carefully brush the pipe and fitting ends to remove any shavings. Confirm this by pushing the *enter* key. Wait for confirmation of the correct heater element temperature (5 seconds) and position the heater element when the display indicates *ready for fusion.*
8. Immediately (within 3 seconds) bring the pipe and fittings in proximity to the heater element until the stops are contacted. Hold until the heating time is completed (timer counts to 0).
9. Immediately retract the pipe and fitting, slide to the right and push away the heater element (on IR 63, the heater element is spring-loaded).
10. Bring the parts together within allowed time as indicated on the display, and push the slide down until the cam-lock is engaged. Allow to cool until cooling time expires.

Examine the fusion coupon and confirm its conformance to PVDF fusion guidelines. It shall have uniform double beads on the pipe OD in accordance with the following chart:

PVDF Wall Thickness	Fusion Bead Width (mm) Minimum	Maximum
2	1.5	3
3	2	3.5
4	2.5	4
5	3	5
6	3.5	5.5
7	4	6

The joint shall have no offset or misalignment greater than 10% of the pipe wall, and can have no visible inclusions, dirt, specs, or other contamination in the fusion area. The midpoint of the OD fusion bead shall never be less than the pipe surface.

Socket-Fusion Procedure:

1. Select coupon material of suitable length to be fully supported and confirm correct pipe and fitting clamps, machine alignment and pipe stops, heated plate, and confirm that adjustments are correctly set for high-purity heat-fusion.
2. Peel end with appropriate GF peeling tool.
3. Place properly cut and peeled pipe in clamps using the pipe stops and fittings in the jaws, and using the squaring plates provided with the fusion machine.
4. Clean the pipe OD and fitting socket using IPA and Anticon 100 wipers.
5. Check alignment, penetration stops, and heater bushing depth.
6. Clean heater bushing using Anticon 100 wiper.
7. Insert pipe and fitting onto the heater bushings and heat until a uniform bead of approximately $^1/_3$ of the pipe wall thickness can be observed on the pipe side. Time charts are used as guides.
8. Quickly pull pipe and fittings off heater plate using a snapping motion, and swing the heater plate out of the way.
9. Immediately bring the pipe into the fitting socket and fully insert until the outside fusion beads meet. A $^1/_{16}$" to $^1/_8$" gap between the inside fusion bead and the bottom of the socket should be present.

10. Allow the pipe and fitting to cool approximately the same time as heating. Remove the fused joint from the machine and inspect the fusion beads and alignment.

Examine the fusion coupon and confirm its conformance to PVDF fusion guidelines. The joint shall be free of voids in the socket area, and shall have 100% bead formation at the socket entry point with no visible cracks. It should have a 1/16” to 1/8” gap between the inside fusion bead and the socket bottom to allow a flushing action, and should be free of any visible contamination, specs, dirt, or inclusions on the wetted surfaces. It must have no bead protruding into the pipe inside diameter in excess of 1/3 of the pipe wall thickness, and should not deform the pipe roundness at any point. The joint should be even around the circumference.

If the fusion coupon does not conform to the criteria listed above, make the necessary alterations on the machine and repeat the heat-fusion process. If two attempts to correct the situation are unsuccessful, notify your supervisor.

If the fusion coupon does conform to the criteria above, make the appropriate entry into the fusion log – use the fusion printout if available – marking time, date, fuser ID serial number, and lot numbers on the coupon. Attach the printout (IR) to the fusion log.

Pressure Testing and Analytical Testing Procedures

On completion of the connections to the tool, coordinate with the tool owner for pressure and analytical testing. Tag and shut the DI Supply and DI Return isolation valves to the tool and open the bypass valve, if present. Install pressure and analytical test assembly on the DI Return sanitization port. Run the drain line from the analytical test assembly to a process waste drain.

Equipment owner will verify test setup and open the supply valve long enough to pressurize the loop, then close the valve. Check for leaks. If there are no leaks, record the time and pressure and hold for one hour. Check system after one hour and verify that there is no decay in pressure.

After satisfactory pressure test, begin flushing the loop. Equipment owner supervises the opening of the isolation valve. Flush the monitoring system until a resistivity of at least 17.5 megohm-cm is achieved. The particle counter is attached to the system and the water sampled. A maximum of 2 particles per milliliter at 0.2 µm are allowed.

Open the DI Return isolation valve to establish flow, shut the sanitization outlet, and disconnect the test assembly. Document the results and notify the equipment owner and construction supervisor of the test results.

Piping supports

For supporting PVDF piping for DI water or other solutions of like specific gravity, please use the following table:

Nominal	Operating Temperature			
Pipe Diameter	**68 F**	**104 F**	**140 F**	**176 F**
½”	3.1’	2.9’	2.6’	2.5’
¾”	3.3’	3.1’	3.0’	2.8’
1”	3.6’	3.3’	3.1’	3.0’
1 ¼”	4.1’	3.8’	3.6’	3.0’
1 ½”	4.6’	4.3’	3.9’	3.7’
2”	4.9’	4.6’	4.3’	3.9’
2 ½”	5.4’	5.1’	4.6’	4.3’
3”	5.9’	5.4’	5.1’	4.8’
4”	6.6’	6.1’	5.8’	5.3’
6”	7.1’	5.9’	5.0’	4.2’

4.5.2. Liquid-Chemical Piping Systems

Outer containment lines

Outer-containment lines for chemical systems are to be clear PVC or an alternate material approved by a consensus of the lab staff. Leak-proof joining technology, such as solvent welding, must be used at all joints. Leak sensing is to be provided at suitable low-points in the line.

Primary chemical lines

Primary chemical lines must be continuous Teflon™ PFA tubing. In rare cases, an alternative tubing may be required for chemical compatibility – consensus approval of the lab staff is required. Tubing joints may not be within the outer-containment piping but must be contained in junction boxes or valve boxes. All valves, whether joined or welded, must be contained within approved valve boxes.

4.6. FIRE-SERVICE PIPING

All sprinkler heads used in corrosive atmospheres must be beeswax coated or equivalent.

A sprinkler head is required at the transition piece of a combustible tool's connection to the exhaust system.

Sprinkler protection is required on all combustible tools that do not have a built-in fire suppression system.

All valves used in fire-service piping must be UL listed or FM Approved.

Connect sprinkler heads to exhaust systems using approved flexible connectors (e.g., FlexHead™).

All fire-service piping must be painted red. Paint approved for use in the cleanroom must be used. The exception is fire-service piping located within a corrosive environment. Properly labeled stainless steel piping is acceptable in this application.

4.7. MECHANICAL VACUUM PUMP SYSTEMS

Mechanical (roughing) vacuum pump systems must always be located in the subfab. These pumps generate large numbers of particles and non-particle airborne contamination, have significant cooling requirements, and servicing the pumps contaminates surrounding areas. For these reasons, mechanical vacuum pumps are not to be located in the cleanroom or chase.

All vacuum pumps must be vibration-isolated from the subfab floor. Unless included in the pump package, it is recommended that vacuum pumps be placed on a vibration-isolation pump stand. In addition to minimizing the vibration transmitted from the pump, these stands bring the pump to a much more convenient height for servicing. Vacuum pump stands are generally 18"-30" in height, and vary in length and width based on the size of the vacuum pump.

Connection to the appropriate exhaust system is critical. Please follow the instructions carefully. First, an oil-mist eliminator (sometimes called a filter) must be placed on the downstream side of the pump (except dry pumps), upstream of the tie-in to the exhaust system. The tie-in uses a slip-fit design. This prevents over-pressurizing the exhaust and under-pressurizing the pump during varied pumping cycles. As a guide, please consider the following table:

Pump Exhaust	Exhaust Sleeve
1 inch	2 ½ inches
1 ¼ inches	3 inches
1 ½ inches	4 inches
2 inches	5 inches
2 ½ inches	6 inches
3 inches	7 ½ inches
4 inches	10 inches

There are three types of mechanical vacuum pumps commonly used on process equipment in the facility. Dry pumps are used on processes which develop high particle concentration in the effluents. Fomblin™-compatible pumps are used for various applications, and always when oxygen concentrations greater than 20% are used as a process gas. In some other cases, hydrocarbon-compatible pumps are used. Please note that Fomblin-compatible pumps and hydrocarbon-compatible pumps are not interchangeable – they have different internal clearances.

On dry pumps, it is a good practice to put a manual gate valve above pump to be able to close the foreline, vent the line at the tool, but still keep the dry pump turned on. This prevents the dry pump from locking up during service of the tool.

Pumping systems generally fall into two categories: critical and noncritical. Critical systems are concerned with conductance losses in the piping systems, noncritical systems do not share this concern. Critical systems may need to oversize the pumping line to minimize conductance, and oversize the vacuum pump to compensate for the larger volume being pumped. It is also advisable to eliminate (or at least minimize) 90° bends by substituting two 45° bends.

4.8. DRAIN SYSTEMS

Penetrating existing drain system requires significant care. First, it must always be assumed that drain systems contain significant quantities of hazardous wastes, therefore full personal-protective equipment (PPE) is required. At a minimum, this includes a chemical-resistant jumpsuit (Level B) with hood, goggles, and chemically-resistant gloves.

The first precaution prior to penetration of the drain system is to ensure that no material is entering that section of piping. This requires lockout of equipment feeding that drain and careful coordination of the activity.

The second precaution is to purge the drain line, to the extent possible. Only at this point can the drain be penetrated.

It is also important that all parts removed from the drain system be thoroughly rinsed with water or, in rare cases, with a different solvent, to ensure that no hazardous materials remain. These parts can then be disposed of in the appropriate container.

4.9. AIR-HANDLING SYSTEMS

Additions to the air-handling system have two major considerations: modification of airflow through the remaining system and cleanliness of the air-handling ductwork and plenums.

It is required that a rebalance of the air handling system take place when additional drops and filters are added to the system or drops and filters are removed from the system. If filters are removed from the system, the filter and filter housing are to be enclosed in Visqueen and stored in an appropriate location.

If drops and filters are to be added to the system, it is greatly preferred to use existing stubs in the balancing boxes and draw the air from them. If it is necessary to add to the available number of drops, consultation with our balancing contractor must take place. The most appropriate location for a new balancing box and the feed of that box will be determined.

Any cutting into air-supply ductwork requires careful cleanliness practices. First, the duct or plenum being penetrated must be pressurized to minimize the infusion of contamination. Cleaning vacuum must be applied during the penetration process, and any loose debris must be removed from the interior of the duct with a cleanroom wiper moistened with isopropyl alcohol. Burrs are to be removed with a cutting tool – such as tin snips – not with a file. Finally, the area around the penetration must be thoroughly cleaned.

Biocleanroom guidelines

4.10. Exhaust Systems

General Exhaust: The presence of flammable/explosive materials in this duct is likely, so a great deal of care must be exercised when cutting into the duct or welding to the duct. This includes, but is not limited to, purging of the ductwork. Signs must be placed on the floor below the duct to warn pedestrians that the duct is being penetrated.

When connecting vacuum pumps to exhaust systems, each pump must have an individual connection to the exhaust. No manifolding of pumps is allowable. Between the vacuum pump and the exhaust connection, and oil-mist eliminator is required, unless the vacuum pump is a "dry pump" – uses no vacuum pump oil of any type.

Scrubbed Exhaust: The presence of corrosives in these ducts is likely, so proper protective equipment must be used whenever the duct is penetrated. At a minimum, this includes an acid-protective jumpsuit, goggles, and acid-resistant gloves.

In addition, any equipment, electrical busses, etc. below the duct must be protected from spillage when working on the duct. Signs must be placed on the floor below the duct to warn pedestrians that the duct is being penetrated.

Biocleanroom guidelines

4.11. Electrical Systems

It is critical that electrical cords and flexible data cables be kept off the floor to facilitate cleaning. The alternative is to create a raceway that is sealed and that allows cleaning on all sides of the raceway.

No electrical power or data cord may penetrate a laboratory wall, cleanroom wall, waffle slab, or raised floor unless it passes through a protective sleeve or escutcheon.

All electrical connections must be torqued to the manufacturer's specifications.

Electrical inputs into boxes, power supplies, panels, etc. must be sealed, or conduit must be used.

4.12. Penetrations through the Raised Floor

Before making penetrations through the raised floor, a consensus decision of the lab staff must be reached to ensure that access to both the chase and the equipment is maintained and that the area around the penetration is cleanable. Except in very rare instances, all penetrations through the raised floor must be in the chase area.

Whenever practical, all drilling of the floor panel should be made outside the cleanroom. The panel is then cleaned and brought back into the cleanroom. It is recognized that in some cases, it is necessary to drill a floor panel in place (such as when other utilities already penetrate the panel). In these cases, care must be taken during the drilling process to minimize contamination. Drilling through a large tee, as described in the wall-penetration section, is the preferred method. It must also be noted that the area beneath the drilling location must receive special care in cleaning up any debris that falls below the panel.

4.13. Penetrations through the Waffle Slab

Many penetrations of the waffle slab already exist, and it is highly preferable to use those penetrations even if it increases the utility run length. It is recognized, however, that there will be instances where the waffle slab must be penetrated, using a core-drilling apparatus.

Whether in the chase area or in the cleanroom, it is important that core-drilled holes are not left open. Holes less than 8 inches in diameter may be sealed with duct tape and Visqueen after drilling; larger holes must be covered with a steel plate and sealed with duct tape. ***Note:*** When permanently filling a core-drilled hole following utility tearout, holes greater than 8 inches in diameter, reinforcement rod must join the patch to the remainder of the flooring.

Penetrating the concrete floor of the cleanroom is a very dirty job, sending huge particle storms throughout the area. It is important, therefore, to provide the maximum amount of isolation possible while performing this task. Temporary walls and covering nearby return-air grilles are a minimum requirement. A custodian should be present any time core-drilling operations are underway to assist in the control of the contamination created by the core-drilling operation.

All gas cabinets, vacuum pumps, substations, etc. located below the penetration must be covered with Visqueen during the core-drilling process to minimize soiling of these items. Ample warning must be given to personnel below the core-drilling area to ensure they are not hit by falling debris.

Using a great deal of water while core-drilling will help to minimize the number of airborne particles, but it is critical that the cleanroom adjacent to the core-drilling be cleaned using a vacuum-mop-vacuum procedure **while the slurry is still wet**. The core-drilling tool itself must be cleaned in place, while it is still wet. Following the removal of the tool and the temporary walls, the cleanroom area must be cleaned again and checked for particle levels using a Q3 Surface Particle Counter. The subfab area must be cleaned immediately following the cleaning of the cleanroom.

Following the completion of the connections through the floor, the core-drilled opening must be sealed with 3M Fire Barrier Putty No. 303. It is critical that this seal is leak-tight to prevent air circulation from the subfab and to prevent spills from reaching the basement.

4.14. WALL PENETRATIONS

Penetration of the aluminum honeycomb wall panels can result in a shower of contamination during the drilling process. Whenever practical, the panel is to be removed from the wall and taken out of the cleanroom for the drilling (or cutting) and sealing process. The panel must be thoroughly cleaned before reentry into the cleanroom.

It is understood that there are times when it is not practical to remove the panel to be cut, such as when additional utilities are already penetrating the panel. To minimize the effects of the drilling operation when the operation must be done in the cleanroom, vacuum must be used on both the interior and exterior surface being drilled. The interior surface (drill side) is protected by using a PVC tee fitting large enough to accommodate the drill chuck. The vacuum cleaner is attached to the stem of the tee, and the drilling is done through the straight portion of the tee. At the same time, a second vacuum cleaner outlet must be used to protect the exterior surface of the wall panel. Following drilling, the surface of the hole must be wiped with an Anticon 100 cleanroom wiper while the vacuum is still present. Take special care to ensure that no sharp edges remain, and that any metal burrs have been removed.

Following the wall penetration, the area adjacent to the penetration must be wiped with an Anticon 100 cleanroom wiper moistened with TechniPure solution. The surface must then be checked with a Q III Surface Particle Monitor and re-cleaned as necessary.

All wall penetrations must be sealed with a white polyurethane sealant, whether or not an escutcheon or trim piece is to be installed.

Larger holes that require a saw-cut rather than drilling are to use a similar method, where vacuum is used on both sides of the panel while it is being cut.

When a large number of utilities penetrate a wall panel, it is often advisable to create a conduit for the utilities between the chase and the equipment. The ability to clean this conduit and the area around it are the critical factors in this design. The conduit must be sealed to the equipment and sealed to the chase on the ends, and must provide a reasonably airtight chamber. The conduit must be either sealed to the floor or located at least 6 inches above the floor to allow cleaning beneath the conduit.

4.15. TEMPORARY WALLS

Whenever practical, the equipment-installation area should be isolated by temporary walls. Temporary walls are constructed of a framework of 2”x4” lumber wrapped in Visqueen, with Visqueen panels on the inside and outside of the framework. They are generally wedge-fit against the cleanroom ceiling.

When constructing temporary walls, air return must be considered. An enclosure constructed with air input and no return will overpressurize and knock down the temporary wall! It is also important to ensure that the air from the equipment-installation area is routed to an area where the increased contamination will not be an issue.

It must also be noted that the construction of temporary walls does not allow EVERYTHING to be done inside the enclosure. The walls serve as a further barrier to contamination migration, but tasks performed in the enclosure must be limited to relatively clean activities.

When the equipment-installation performed within the enclosure is complete, a thorough cleaning of the area must be completed before the temporary walls are removed. If the enclosure is adjacent to critical areas, the surfaces inside the enclosure must be certified as clean using a Q III Surface Particle Detector prior to the removal of the walls. Following the removal of the walls, a final cleaning (vacuum-mop-vacuum protocol) is performed, and the Q III is used to verify cleanliness.

4.16. LABELING REQUIREMENTS

4.16.1. Cleanroom and Chase Labels

Piping in Cleanroom and Chase (above and below the raised floor)

All wall penetrations above and below the raised floor must be labeled. All labels must be placed on the wall above the penetration if the penetration is less than or equal to 60 inches above finished (raised) floor (AFF) or below the raised floor. Where penetrations are above 60 inches AFF, the label must be placed below the penetration. Where practical, labels should be placed on the escutcheon plates.

Filter housings must be labeled with the gas or liquid that is being filtered. The filter housing must also be labeled with the manufacturer and model number of the filter cartridge (or disposable filter assembly). the replacement (installation) date of that cartridge (assembly), and the initials of the person installing the cartridge.

All horizontal and vertical runs greater than 24 inches in length must be labeled. Labels must be no more than 6 feet apart. Flow direction arrows are required in all runs where there is a definitive flow direction. Labels are not required on equipment connections that are less than 24 inches in length, nor are they required on flexible piping.

Labels are required on the equipment connections whenever practical. If vendor labels are present, they must meet these labeling requirements and must match the nomenclature in this document, or must be supplemented or replaced (preferred) by labels that meet these requirements.

Exhaust Labeling

In the chase, all exhaust ducts that penetrate the raised floor must be labeled 2 inches AFF. Labels must be placed on both sides of the duct, in the most visible directions.

In the cleanroom, all floor penetrations that penetrate the raised floor must be labeled 2 inches AFF on the most visible side(s) of the duct. Wall penetrations below 46 inches AFF must be labeled above the duct. All wall penetrations above 46 inches AFF must be labeled below the duct. All ceiling penetrations must be labeled 2 inches below the ceiling on the two most visible sides of the duct.

In both the cleanroom and chase, all floor penetrations that do not penetrate the raised floor must be labeled 2 inches above the top surface of the waffle slab. Labels must be placed on the two most visible sides of the duct.

Electrical Labeling

All disconnect boxes and electrical panels must be labeled. Site Excel spreadsheet updated and posted in panel directory.

All outlets – twistlock or conventional – must be labeled on the escutcheon plate as to the location of the disconnect or breaker. All direct-wire connections to equipment must be labeled on the equipment, as close to the connection point as practical.

Equipment Labeling

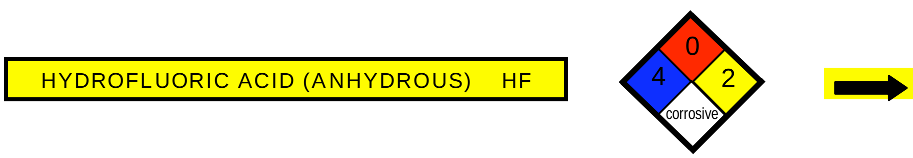
All equipment in the cleanroom must have a label identifying that piece of equipment. The equipment designator and the label are obtained from the BNC staff, and include a descriptor with a location code. All equipment located within the cleanroom envelope – cleanroom bays and chases – are to use the layout number (e.g., N-25) as the location code. Support equipment, including that located in the subfab and plenum, is labeled with a designated label that includes the identifier for the equipment supported.

Label Descriptions

Labels must be of a non-contaminating material suitable for cleanroom use. Label must adhere to wall, piping, ductwork, conduit, and electrical box materials through the routine cleaning of these surfaces.

Labels shall have printed letters on a high-contrast background. Electrical labels shall have black letters on a white background, low-hazard gases shall have white letters on a blue background, low-hazard liquids shall have white letters on a green background, and hazardous materials shall have black letters on a yellow background. Flow direction arrow labels shall match the label colors for that system.

Piping and exhaust labels must follow the nomenclature listed under System Descriptions in this document. All chemical names will be spelled out. Chemical formulae usually are used as a supplement to the spelled-out name of the chemical but may ***not*** be used in place of the spelled-out name. Hazardous gases and liquids must also have the NFPA Diamond following the chemical name and formula, if the pipe/tubing diameter allows. For example, a label for anhydrous hydrofluoric acid may look like the following:



Electrical labels will correspond to the source of the electrical service, unless otherwise noted above. Bus plugs and vacuum pump starter units will be labeled with the panel or equipment it feeds. Electrical panels will be labeled with the chase number and serial designator for the panel (e.g., JK Panel 1). Receptacles will be labeled with the panel designation, then the breaker within that panel (e.g., JK Panel 1 Ckt 24). Conduit will be labeled with the breaker designation of the source. Remote control devices will be labeled according to the unit they control.

Piping, exhaust, electrical conduit, and receptacle labels will be as large as practical for the pipe size they are marking, according to standard label sizes. Electrical panel labels shall be 1 inch high with $^{3}/_{8}$-inch-high letters.

4.16.2. Subfab Labels

Piping

Horizontal runs over 2 feet in length must be labeled. Large labels (2 ½” x 14” or larger) must be no more than 20 feet apart. Small labels must be no more than 10 feet apart.

All pipes must be labeled at the valve off the main. Flow direction labels are required at each label point on a run, unless the system is a loop-supply system.

Vertical runs over 2 feet in length must be labeled. All piping must be labeled where it penetrates a wall, floor, or ceiling.

Exhaust

Two-foot diameter and larger ducts over 10 feet in length must be labeled. Labels must be no more than 20 feet apart. Elevation changes of more than 4 feet designate a new run, and must be labeled according to the preceding guideline.

Ducts less than two feet in diameter over 10 feet in length must be labeled. Labels must be no more than 10 feet apart. All ceiling, floor, and wall penetrations must be labeled on ductwork on two sides.

Flow-direction arrows must be used at all label locations.

Electrical

All disconnect boxes and electrical panels must be labeled. Site Excel spreadsheet updated and posted in panel directory.

All outlets – twistlock or conventional – must be labeled on the escutcheon plate as to the location of the disconnect or breaker. All direct-wire connections to equipment must be labeled on the equipment, as close to the connection point as practical.

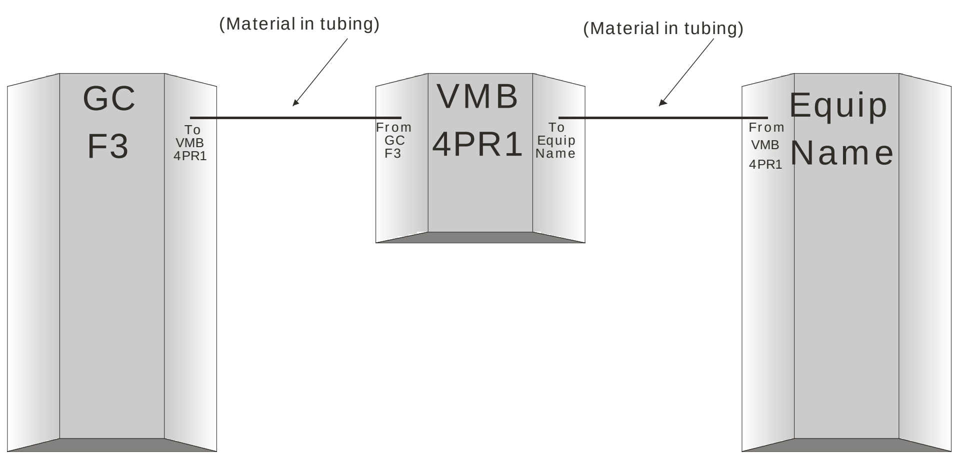
Labels will correspond to the source of the electrical service. Bus plugs and vacuum pump starter units will be labeled with the panel or equipment it feeds. Receptacles will be labeled with the panel designation followed by the breaker number within that panel. Conduit will be labeled with the panel designation of the source, then the circuit. Remote control devices will be labeled according to the unit they control.

Equipment Labeling

All equipment in the subfab must have a label identifying that piece of equipment. The equipment designator and the label are obtained from the lab staff, and include a descriptor and a location code. The location code will reference the layout number of the principal equipment in the cleanroom. Support equipment is labeled with a designated label that includes the identifier for the equipment that is supported.

Gas cabinets, VMBs, and equipment supplied with gases from gas cabinets and/or VMBs must be labeled on the gas inlet ***and*** gas outlet side of the unit. The label on the gas cabinet must indicate the VMB and/or equipment supplied. The input side of the VMB must indicate the gas cabinet(s) from which the VMB is supplied. The output side of the VMB must indicate the equipment name of the equipment supplied by the VMB. The input side of the equipment must be labeled with the name of the VMB(s) and/or gas cabinet(s) that supply the equipment.

VMB Labeling Scheme

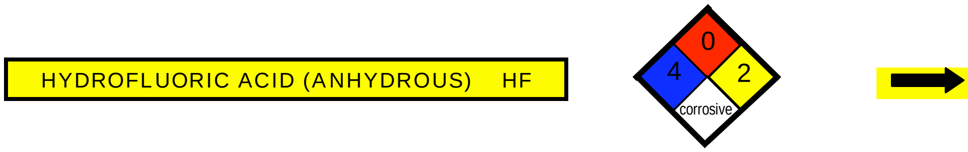


Label Descriptions

Labels must be of a durable material and must adhere to wall, piping, ductwork, conduit, and electrical box materials through the routine cleaning of these surfaces.

Labels shall have printed letters on a high-contrast background. Electrical labels shall have black letters on a white background, low-hazard gases shall have white letters on a blue background, low-hazard liquids shall have white letters on a green background, and hazardous materials shall have black letters on a yellow background. Flow direction arrow labels shall match the label colors for that system.

Piping and exhaust labels must follow the nomenclature listed under System Descriptions in this document. All chemical names will be spelled out. Chemical formulae may be used as a supplement to the spelled-out name of the chemical but may ***not*** be used in place of the spelled-out name. Hazardous gases and liquids must also have the NFPA Diamond following the chemical name and formula if pipe/tubing size allows. For example, a label for anhydrous hydrofluoric acid may look like the following:



Electrical labels will correspond to the source of the electrical service, unless otherwise noted above. Bus plugs and vacuum pump starter units will be labeled with the panel or equipment it feeds. Electrical panels will be labeled with the chase number and serial designator for the panel (e.g., JK Panel 1). Receptacles will be labeled with the panel designation, then the breaker within that panel (e.g., JK Panel 1 Ckt 24). Conduit will be labeled with the breaker designation of the source. Remote control devices will be labeled according to the unit they control.

Piping, exhaust, electrical conduit, and receptacle labels will be as large as practical for the pipe size they are marking, according to standard label sizes. Electrical panel labels shall be 1 inch high with $^{3}/_{8}$-inch-high letters.

4.16.3.   Label Sizes

All labels shall comply with the attached size chart, per ANSI A13.1:

Outside Diameter of pipe, tubing, or covering		**Length of Color Field (min)**		**Size of Letters**	
in	**mm**	**in**	**mm**	**in**	**mm**
< ¾	< 19	2 ¾	65	$^{5}/_{16}$	9
¾ to 1 ¼	19 to 32	8	200	½	13
1 ½ to 2	38 to 51	8	200	¾	19
2 ½ to 6	64 to 150	12	300	1 ¼	32
8 to 10	200 to 250	24	600	2 ½	64
Over 10	Over 250	32	800	3 ½	89

4.16.4.   Status Labeling

All exhaust drops, hazardous liquid and gas supply piping and liquid drain piping must receive temporary labels during the equipment installation process. These labels will inform anyone working around the piping of the status of the piping installation and the associated piping. Piping labels must be located at all branch valves on the system branch being modified Drain systems must be labeled at all drain inputs on the branch. Exhaust ducts must be labeled within three feet of the end of the duct being modified and at all capped exhaust lines on that branch. The following labeling scheme will be used:

Material	***Status***	***Color***	***Wording***
Hazardous Gas	Piping installed, not leak-tested	Orange	PIPING NOT TESTED
Hazardous Gas	Piping tested, not charged	Green	PIPING TESTED
Hazardous Gas	Piping charged with hazardous gas	Red	HAZARDOUS MATERIAL PRESENT
Hazardous Liquid	Piping installed, not leak-tested	Orange	PIPING NOT TESTED

Hazardous Liquid	Piping tested, not charged	Green	PIPING TESTED
Hazardous Liquid	Piping charged with hazardous liquid	Red	HAZARDOUS MATERIAL PRESENT
Drain	Drain not connected	Orange	DRAIN NOT CONNECTED
Drain	Drain functional	Red	DRAIN IN USE HAZARDOUS MATERIALS PRESENT
Exhaust	Exhaust not connected	Orange	EXHAUST NOT CONNECTED
Exhaust	Exhaust in use, hazardous materials present	Red	EXHAUST IN USE HAZARDOUS MATERIALS PRESENT

Piping and exhaust will be labeled with 3 x 6 coated labels with the wording shown above and: 1) The name and formula of the material present (except exhaust and drain); 2) The name of the person placing the label; and 3) The date the label was placed.

4.17. EQUIPMENT MOVEMENT AND PLACEMENT

By necessity, movement of equipment between the dock and the cleanroom and within the cleanroom requires some compromises. Movement between the dock area and the cleanroom is by conventional means – fork lift, etc. It is important, however, to maintain the integrity of the outer packaging to maintain the cleanliness level of the equipment inside.

When the equipment is moved into the cleanroom – after precleaning – certain protocols must be observed. Also, equipment relocated within the cleanroom must follow these same protocols.

First, the devices used for moving the equipment must be made of non-contaminating materials and must be thoroughly cleaned. A set of the most common items – dollies, roller lifts, etc. – must be thoroughly cleaned and kept in the cleanroom for cleanroom use only. If additional items are required, they must be thoroughly cleaned in the equipment-cleandown area prior to each entry into the cleanroom.

Second, the cleanliness level and gowning protocol of those people moving the equipment must match the cleanliness level and gowning protocol of the equipment destination. That is to say, if equipment is being moved into the general cleanroom area, the gowning protocol and practices of those moving the equipment must match general cleanroom protocols. If a temporary wall has isolated the equipment-installation area to a lesser cleanliness standard, then only the lesser standard must be maintained while moving the equipment.

4.18. EQUIPMENT CLEANING

The amount of cleaning necessary for process equipment depends on the level of cleaning performed prior to shipment and the integrity of the packaging. This section will be broken into two parts based on those criteria

4.18.1. Equipment not cleaned to ISO Class 5 (Class 100) Level or packaging breached

The packaging is removed at the dock (or designated depackaging area) and equipment is cleaned using TechniPure and DI water with Anticon 100 wipers. If gross contamination is present, stronger cleaners may be used but must be followed by cleaning with TechniPure. Once this precleaning complete, the equipment is moved to the equipment entry area and the procedure for factory-cleaned equipment (4.19.2) is followed.

4.18.2. Equipment cleaned to ISO Class 5 (Class 100) Level at point of shipment, packaging intact

Any crates and/or skids that are external to the packaging of the equipment are removed at the dock (or designated depackaging area). The equipment is then moved into the equipment entry area with the packaging intact.

The factory packaging is removed, and the equipment is transported into the cleanroom. When set in place and the utilities installed, the equipment is cleaned using DI water and isopropyl alcohol. If spots are present, TechniPure may be used but should be followed by wiping with DI water. Anticon Gold (or Anticon 100) wipers are used for the cleaning. The cleaning of the equipment must include cleaning the exterior of the utility connections to the equipment, all the way to the raised floor or chase wall. If bulkhead mounted, the cleaning of utilities is to extend to the raised-floor penetration.

Ancillary equipment must be cleaned using the same procedures.

Note: In all cases, consult with the equipment owner regarding the cleaning of delicate or potentially sensitive areas of the equipment.

4.19. POST-CONSTRUCTION CLEANING

When installation is complete, a final cleaning of the equipment-installation area is required. This begins with a wipe-down of the ceiling grid using isopropyl alcohol and Anticon 100 wipers. Following this, the walls are wiped using TechniPure and the Texwipe Wall Wiping System. Anticon 100 wipers must be used for all non-flat surfaces, including mullions. Finally, the floor is cleaned using a vacuum-mop-vacuum protocol. Careful attention must be paid to areas near equipment and near utility connections.

Following the final cleaning, the area must be evaluated for cleanliness using two methods. First, the wiper test involves wiping surfaces with a white cleanroom wiper and a black cleanroom wiper and examining the wipers under bright light. If this test is passed, then the Q III Surface Particle Detector is used to evaluate the cleanliness of the surface for sub-micrometer particles.

If any of the tests fail, the cleaning process is repeated for that surface and for all surfaces that were cleaned after that surface. For example, if the wall fails, the floor must be re-cleaned as well. If the floor fails, then only the floor must be re-cleaned.

5. THE INSTALLATION PROCESS

5.1. TRAINING

All trades working in the Birck Nanotechnology Center must have received the appropriate training courses, including ***Cleanroom/Biocleanroom/Laboratory Equipment Installation Training***. Field service personnel working for a limited time under the supervision of Birck residents may be eligible for a shorter training course.

Additional training is job-specific. It must include what is necessary to perform their job, and to operate in a safe manner. For example, plumbers cutting into hazardous gas lines would be required to have Self-Contained Breathing Apparatus (SCBA) training.

5.2. UTILITY INTERRUPTION COORDINATION

It is key to the successful operation of the Birck Nanotechnology Center that any interruption that has a reasonable likelihood of interrupting utilities in operating portions of the cleanroom or laboratories be carefully coordinated through the BNC Lab Staff.

5.3. CLEANROOM PROTOCOL

Cleanroom protocols are established for the area in which the work is being performed. If the equipment installation area is open to the remainder of the cleanroom, full cleanroom protocols (refer to BNC Operating Procedures - Cleanroom) must be observed. If the area is isolated from the cleanroom, the protocol for the isolated area will be established.

5.4. OBSOLETE UTILITY REMOVAL

Part of the job involved in the removal of old equipment is the removal of obsolete utilities – **disconnected utilities must not be left in place.** All DI must be stripped back to the branch with a loop installed to the return. PCW must be stripped back to the mains, gas cabinet lines must be stripped back to the gas cabinet, electrical power must be stripped back to the bus head or distribution box, and other utilities must be stripped back as far as practical. **Utilities may be left in place if they are to be used on a piece of equipment that is on order or awaiting installation.**

It is critical that the tear-out of hazardous materials lines leaves the facility in a safe condition. All materials – piping, valves, gauges, etc. – must be disposed of properly. Also, it is not acceptable to terminate a hazardous line with a closed valve – a cap must be installed downstream of the valve. Please note that the valve must also be locked out.

After the removal of utilities, the area must be restored to a “like new” condition. This involves replacement of wall panels and raised-floor panels that have been penetrated, patching the floor at any breaches, and other similar tasks.

5.5. EQUIPMENT DOCUMENTATION

All documentation used in the cleanroom during equipment-installation must conform to the cleanroom protocol level in that area. For example, if an area is open to the remainder of the cleanroom, documentation must be on cleanroom paper or must be laminated and wiped down with isopropyl alcohol prior to cleanroom entry.

5.6. DESIGN REVIEW

A design review of all equipment-installation designs will be held prior to the installation of the equipment. This design review will involve representatives from Purdue Engineering – Electrical, Mechanical, and Public Safety – as well as BNC Building/Facility management, the Equipment and Process Owner assigned to the equipment involved, and other contributing parties. The design review will be a working meeting, generally resulting in a design that meets the consensus of the team. An alternative outcome, which should rarely occur, is that further analysis or effort on the design is needed. When practical, the information to be discussed in the meeting should be e-mailed to the participants two days in advance of the meeting.

5.7. PRE-CONSTRUCTION MEETING

Immediately prior to the beginning of equipment-installation, a pre-construction meeting is held. This meeting will be called by the equipment owner, and attended by the electrical engineer, the mechanical engineer, the REM representative, and the appropriate project trades. The purpose of the meeting is to review the installation plan and make specific plans on how the installation will be accomplished. The Pre-Construction checklist will be filled out in this meeting. The original of the checklist is to be retained by the equipment owner. Is a copy to be filed with Physical Facilities?

5.8. POST-CONSTRUCTION MEETING

Following the completion of an equipment-installation project, a post-construction meeting is to be held. This meeting is to be initiated and chaired by the equipment owner, and attended by electrical and mechanical engineers, and the REM representative. The purpose of the meeting is to review the finished equipment-installation project and "sign off" the installation. The Construction Completion Checklist will be used as the primary reference documents for this meeting, and will be filled out at the meeting. The equipment-installation project is not considered complete until the post-construction meeting has been held and all necessary parties have signed the Construction Completion Checklist. The equipment owner retains the original of this checklist. Is a copy to be filed with Physical Facilities?

6. SUPPLIMENTAL INFORMATION

6.1. CHARTS

6.1.1. Gaseous Chemical Compatibility Chart

6.1.2. Liquid Chemical Compatibility Chart

6.1.3. Gas Hazard Chart

6.1.4. Gas Cabinet Checklist

6.1.5. Summary of System Descriptions

6.2. FORMS

6.2.1. BNC Utility Guide

This form is used to designate the utilities that will be needed for the installation and provides a guide to the utilities that are available in the Birck Nanotechnology Center.

6.2.2. Post-Purchase Order Checklist

This form is to be used by the equipment owner to ensure that all issues have been evaluated.

6.2.3. Pre-Construction Meeting Checklist

This form is to be filled out during the Pre-Construction Meeting. The completion of this form signals the beginning of the equipment-installation activity on the project.

6.2.4. Construction Completion Checklist

This form is to be filled out in the Post-Construction Meeting. The completed form signals the completion of the project.

6.2.5. BNC Equipment Installation Manual Variance

This form is to be used to apply for a variance to the Equipment Installation Manual. It is used as the guide to the meeting discussing the variance.

6.2.6. Gas Cabinet Checklist

This form is to be attached to the front of all gas cabinets prior to their startup, and is filled in as the equipment-installation progresses. A process gas is NOT to be turned on until the entire checklist has been filled in and signed.

6.2.7. New Equipment Identification

This form is to be placed on new equipment upon arrival on the dock, and kept with the equipment until taken into the cleanroom.

6.2.8. Vacuum Pump Information

This tag is to be placed on all vacuum pumps, and is to remain on the pump throughout its lifetime.

Gas Cabinet Checklist

Also to be used for Valve-Manifold Boxes (VMBs)

CABINET NUMBER__________ LOCATION_________PROCESS GAS(ES) __________________

EQUIPMENT SERVED ____

BNC STAFF CONTACT __________________________CELL PHONE _______________________

WORK PHONE___________________________HOME PHONE ______________________

Item Number	Description of Work	Date Completed	Verified (Signature)
1	Cabinet set in correct location		T _______________ P
2	Cabinet anchored in place		T
3	Exhaust ductwork connected		T
4	Exhaust flow checked (__________cfm)		R
5	Sprinkler line active		R
6	UN_2 Connection complete and active		T
7	Internal purge/vent lines connected		T
8	Purge vent connected to exhaust		T
9	Process line connected to equipment or VMB		P
10	Inside of cabinet cleaned		H
11	Electrical power connected to panel		T
12	Control panel debugged and operational		P
13	Lines to equipment leak checked		T _________________ P
14	Nitrogen purge cylinder installed		P
15	Nitrogen manifold purged (inside cabinet)		P
16	Lines inside cabinet leak checked		P
17	24-hr pressure test complete, cyl to cabinet		P
18	Labels installed on cabinet (including lock-out)		P
19	Regulator to equipment purged with cyl N_2		P
20	Process gas cylinder delivered		P
21	Process gas cylinder installed and purged		P
22	Approval to turn on process gas		P _________________ R _________________ E

T=Tradesperson P=Process and Equipment Owner R=REM H=Housekeeping E=Purdue Engineering

Gas Compatibility and Like-Hazard Chart

	Ammonia	Argon	Chlorine	Dichlorosilane	Germane	Helium	Hydrogen	Hydrogen Chloride	Krypton:Fluorine	Nitric Oxide	Nitrogen	Nitrogen Trifluoride	Nitrous Oxide	Oxygen	Phosphine	Silane	Trimethyl Silane
Ammonia	♦																
Argon		♦				♦					♦						
Chlorine			♦														
Dichlorosilane				♦													
Germane					♦												
Helium		♦				♦					♦						
Hydrogen							♦										
Hydrogen Chloride								♦									
Krypton:Fluorine									♦								
Nitric Oxide										♦							
Nitrogen		♦				♦					♦						
Nitrogen Trifluoride												♦					
Nitrous Oxide													♦	♦			
Oxygen													♦	♦			
Phosphine															♦		
Silane																♦	
Trimethyl Silane																	♦

Gas Hazard Chart

Gas Name	Formula	Cabinet Type *	Double Containment	Location	Flammability	Reactivity	Health	Physical Hazard	Monitor Required
Ammonia	NH_3	Auto	Yes	Flam	1	0	3		Yes
Argon	Ar	Man	No	Subfab	0	0	U		No
Chlorine	Cl_2	Auto	Yes	Corr	0	0	3		Yes
Dichlorosilane	SiH_2Cl_2	Auto	Yes	Pyro	4	2	3		Yes
Germane	GeH_4	Auto	Yes	Pyro					Yes
Helium	He	Man	No	Subfab					No
Hydrogen	H_2	Auto	No	Bulk	4		0		Yes
Hydrogen Chloride	HCl	Auto	Yes	Corr					Yes
Krypton:Fluorine	$Kr:F_2$	Auto		Corr	0	3	4		Yes
Nitric Oxide	NO	Auto	Yes	Corr					Yes
Nitrogen	N_2	Man	No	Bulk					No
Nitrogen Trifluoride	NF_3	Auto		Corr					Yes
Nitrous Oxide	NO_2	Auto		Corr					Yes
Oxygen	O_2	Auto	No	Bulk					No
Phosphine	PH_3	Auto	Yes	Corr					Yes
Silane	SiH_4	Auto	Yes	Pyro					Yes
Trimethyl Silane	$Si(CH_3)_3$	Auto	Yes	Lab					Yes

* Auto indicates automated cabinet required. Man indicates manual or automated cabinet acceptable.

Summary of System Descriptions

Utility Description	Subfab/Chase		Cleanroom	
	Tubing	Joint	Tubing	Joint
HP Nitrogen	316L	UHP Weld, VCR	316L	UHP Weld, VCR
HP Argon	316L	UHP Weld, VCR	316L	UHP Weld, VCR
HP Oxygen	316L	UHP Weld, VCR	316L	UHP Weld, VCR
HP Hydrogen	316L	UHP Weld, VCR	316L	UHP Weld, VCR
HP Gas Cabinet – Hazardous	316L DC	UHP Weld, VCR	316L DC	UHP Weld, VCR
HP Gas Cabinet or Stand – Inert	316L	UHP Weld, VCR	316L	UHP Weld, VCR
Gas Cabinet – Hazardous	316L DC	UHP Weld, VCR	316L DC	UHP Weld, VCR
Gas Cabinet or Stand – Inert	316L	UHP Weld, VCR	316L	UHP Weld, VCR
Utility Nitrogen	Cu, PFA	Sweat, S-Lok	316L, PFA	Weld, S-Lok
DI Water	PVDF	UHP Fusion	PVDF	UHP Fusion
City Water	Cu, PVC	Sweat, Glue	Cu, PVC, PFA	Sweat, Glue, FlareTek
Lab Cold Water				
Process Cooling Water				
Liquid Nitrogen	VBS	Bayonet	VBS	Bayonet
Process Vacuum	PVC	Glue	PVC, PF	Glue, FlareTek
Roughing Pump Line	316L	Weld	316L	Weld
Acid Waste – Gravity	FRPP	Weld	FRPP	Weld
Acid Waste – Pressure (pumped)	PVC DC	Glue	NA	NA

Birck Nanotechnology Center
Equipment Utility Information

This form is to be completed for each piece of equipment and each piece of support equipment that is to be installed in the Birck Nanotechnology Center as part of the equipment installation package.

Item Name ____

Birck Location: **CLEANROOM** **SUBFAB** **BIOCLEANROOM** **LAB** **OTHER** Lab/Bay ____________

Current Equipment Owner Phone ____________________e-mail __________

Responsible Staff/Tech _________________________Phone __________ e-mail ______________

PRIMARY or **SUPPORT**

If support, name of primary

If primary, does this equipment have support equipment? ______________________________________

If yes, please list: ____

____

NOTE: A separate form must be completed for each support item.

NEW or **RELOCATE**

If New:

Vendor name ____

Vendor contact ______________________________ Phone _____________ e-mail ______________

Delivery date ______________________________ Confidence in date _______________________

If Relocate:

Current location ____

Date available for move-in ____

Is there a backup for this equipment? __________ Maximum allowable down time _______________

Are outside resources needed for equipment relocation or installation? ____________________________

Recommended source ____ ____

Utility Description	HDR Name	Utility Code	Equipment Connections		Utility	
			Number	Size & Type	Usage	Requirements
120-Volt AC Service	120VAC	120VAC			Amp	Φ wires
208-Volt AC Service	208VAC	208VAC			Amp	Φ wires
240-Volt AC Service	240VAC	240VAC			Amp	Φ wires
480-Volt AC Service	408VAC	408VAC			Amp	Φ wires
UPS Power	UPS	UPS				
Earth Ground	GRND	GRND				
Electrical Isolation	ISO	ISO				
HP Nitrogen	N2	HP N_2			cfm	Psi (80 max)
HP Argon	Ar	HP Ar			cfm	Psi
HP Oxygen	O2	HP O_2			cfm	Psi
HP Hydrogen	H2	HP H_2			cfm	Psi
HP Gas Cabinet - NF3 (amonia)	NF3	NF_3			cfm	Psi
HP Gas Cabinet - Kr/F2 (krypton in fluorine)	Kr/F2	Kr/F_2			cfm	Psi
HP Gas Cabinet - HCl (hydrogen chloride)	HCl	HCl			cfm	Psi
HP Gas Cabinet - Cl2 (chlorine)	Cl2	Cl_2			cfm	Psi
HP Gas Cabinet - NO2 (nitrogen dioxide)	NO2	NO_2			cfm	Psi
HP Gas Cabinet - NO (nitric oxide)	NO	NO			cfm	Psi
HP Gas Cabinet - NH3 (amonia)	NH3	NH_3			cfm	Psi
HP Gas Cabinet - B2H6/H2 (diborane in hydrogen)	B2H6/H2	B_2H_6/H_2			cfm	Psi
HP Gas Cabinet - PH3/H2 (phosphine in hydrogen)	PH3/H2	PH_3/H_2			cfm	Psi
HP Gas Cabinet - SiH2Cl2 (dichlorosilane)	SiH2Cl2	SiH_2Cl_2			cfm	Psi
HP Gas Cabinet - C3H8 (propane)	C3H8	C_3H_8			cfm	Psi
HP Gas Cabinet - SiH4 (silane)	SiH4	SiH_4			cfm	Psi
HP Gas Cabinet - GeH4 (germane)	GeH4	GeH_4			cfm	Psi
HP Gas Cabinet - SiCH6 (methylsilane)	SiCH6	$SiCH_6$			cfm	Psi
HP Gas Cabinet - SiH4/Ar (silane in argon)	SiH4/Ar	SiH_4/Ar			cfm	Psi
HP Gas Cabinet - (New)					cfm	Psi
HP Gas Cabinet - (New)					cfm	Psi
HP Gas Cabinet - (New)					cfm	Psi
HP Gas Cabinet - (New)					cfm	Psi
Non-Process (Utility) Nitrogen	UN2	UN_2			cfm	Psi
Clean Dry Air	CDA	CDA			cfm	Psi (85 max)
Utrapure Water Supply	UPWS	DIS			gpm	Psi (30 max)
Ultrapure Water Return	UPWR	DIR			gpm	Psi
Lab Cold Water	LCW	LCW			gpm	Psi
Lab Hot Water	LHW	LHW			gpm	Psi
Sodium Hydroxide	NaOH	NaOH			gpm	Psi
City Water	CW	City			gpm	Psi (55 max)
Process Cooling Water Supply	PCWS	Cooling S			gpm	Psi (80 max)
Process Cooling Water Return	PCWR	Cooling R			gpm	Psi
Process Vacuum	PV	Proc Vac			cfm	Inches Hg
Roughing Pump Systems	ROUGH	ROUGH				
Acid Waste	AW	Acid Drain			gpm	
Acid Waste Neutralization	AWN	Acid Neut				
Condensate Drain	CD	Cond Drn			gpm	
Liquid Nitrogen	LN2	LN_2			lph	
Scrubbed Exhaust	SCE	Scrub			cfm	Inches static
General Exhaust	GE	Gen Ex			cfm	Inches static
Other						
Other						
Other						

New Equipment Checklist

Equipment name:_____________________ **Layout #**_________________ **DATE:**_________________

Model:______________________ **PO Number**___________________

Vendor:______________________ **PIC**___________________

EPRO:______________________ **Expected Delivery Date:**____________________

After PO Issued, obtain the following	**Deliverable**	**Notes**
Do we need "on vendor site" acceptance?	Yes No N/A	
If yes, submit trip request	Trip Request	
If yes, consider predictive maintenance	Schedule	
Number of crates--shipping	Shipping manifest	
Weight of the tool	Each Piece	
Dimension of tool--crated	Shipping manifest	
Dimensions of tool--uncrated	Largest single piece	
Any Special tools required for move in?	Yes No	
Any special cleaning requirements for move in?	Yes No	
Lifting points on tool	Drawing	
Obtain Site Prep manuals	Yes No N/A	
Any special storage requirements?	Yes No	
Need a contact person from the vendor	Name and Phone	
Does vendor need to be contacted for unload?	Yes No	
Does vendor need to be contacted for set up?	Yes No	
Does vendor need to be contacted for install?	Yes No	
Does vendor need to be contacted for start up?	Yes No	
Spare parts list	Yes No N/A	
PM requirements	Yes No N/A	

Vendor Contact

Name_________________________

Phone ________________________

Special tools Required::

Special Cleaning Instructions Required::

Special Storage Requirements::

Other Instructions:::

PRE-CONSTRUCTION CHECKLIST

Layout No.:______________________ **Process and Equipment Owner**______________________

Meeting Date

Layout/Design		Initial	
Installation manual available from vendor	Yes No N/A		
Main tool layout correct	Yes No N/A		
Waffle slab openings acceptable	Yes No N/A		
Auxillary equipment layouts	Yes No N/A		Gas cab, pumps, generators, etc
Electrical designs complete	Yes No N/A		
Mechanical designs complete	Yes No N/A		
Architectural designs complete	Yes No N/A		
Dock date Information		Initial	
Main tool dock date	Date:____________		
All Auxillary equipment available	Yes No N/A		
Pumps available	Yes No N/A		
Gas cabinets available	Yes No N/A		
Installation schedule		Initial	
Job Order information	Charge:		Hours:
Materials available for job	Yes No N/A		Budget:
Start date for installation	Date:____________		
Target date for chemicals	Date:____________		
Estimated Date to completion	Date:____________		
Target date for vendor start up	Date:____________		
Review BNC safety protocol with vendor	Yes No N/A		If vendor on sight for extended time
Miscellanious Items		Initial	
Lockout placards needed	Yes No N/A		
Follow up meeting needed	Yes No N/A		Date:

Issue/Question			Resolution

	Name	Phone	Pager
PIC Contact Information			
BNC Staff Contact Information			

- Over for Meeting Attendance -

This document is to be retained by the equipment owner

PRE-CONSTRUCTION CHECKLIST

Meeting Participation

Position	Signature (indicates agreement with reverse side of form)
Equipment & Process Owner	
PIC	
Facility or Building Manager	
Maintenance Supervisor	
Carpenter	
Electrician	
Plumber	
Tinner	
Custodian	
Other (Specify)	
Birck Safety Coordinator (REM)	
Rigging Contact	

Post-Construction Checklist

Layout Number ________________ Process & Equipment Owner ______________________________
Meeting Date _________________________

Task	*Yes*	*No*	*N/A*	*Initials*	*Comments*
Firestops completed					
Wall penetrations sealed					
Safety showers/eyewashes functional					
Exhaust meets specifications					
TGM system connections tested					
Drains functional and tested					
Gas lines/gas cabinets/VMBs leak checked					
Process & Equipment Owner accepts installation					
All safety requirements met					
EMO's and interlocks tested/verified					
All gas cabinets added to gas const. manual					
All labeling completed					
Chemical cabinet labels in place					
Vacuum pumps labeled					
All facilities turned on to equipment					
Job site cleaned up					
Cords and tubing off floor – area cleanable					
Lockout diagram & procedures in place					
Waste receptacles in place					
Spare parts identified and ordered					
Added to MicroMain system					
PM schedule established					
Monitors added to Siemens system					

Closure signatures

Equipment and process owner ____

Installation supervisor ____

REM ____

Fire and Safety ____

Physical Facilities Engineering ____

BNC Installation Manual Variance

Requested by ________________Phone ________ Supervisor ______________
Need response by__________________ Length of variance ________________
Equipment covered__________________________ Equipment location________

Describe requested variance in detail, including pages referred to in Construction Manual:

____
____
____
____
____

Justification for variance: ____
____
____
____

Justification for length of time: ____
____
____
____
____

Variance: Approved o Disapproved o

Facility Manager ____
Zone Maintenance Supervisor____________________________________
REM Safety Coordinator ____
Building Manager____
Process and Equipment Manager __________________________________
Fire and Safety Representative __________________________________
Physical Facilities Engineering __________________________________

Original to Facility Manager

Vacuum Pump Information

Machine: Name/RTC ________________ Location _____ Oil: Type _________

Pump Location: Pump # __________ Stand __________ Grade ________

Filtration Systems					
Pleated/Alumina/Other	Part #	MR #	Pleated/Alumina/Other	Part #	MR #

Input Gases to Equipment	
Symbol	**Name**

Effluent Gases from Equipment	
Symbol	**Name**

Safety Precautions

PLEASE KEEP THIS TAG ON THIS VACUUM PUMP WHILE HOOKED TO EQUIPMENT. IF THE VACUUM PUMP IS CHANGED, PLEASE PUT A NEW LABEL ON THE REPLACEMENT PUMP.

Revision Log

Date	Document Owner	Change Owner	Description of Changes
10-10-05	J. R. Weaver	J. R. Weaver	Initial Release of Document
11-2-05	J. R. Weaver	J. R. Weaver	Corrected hanger spacing in high-purity piping (4.4.1); Modified section 2.2 to allow for bending of high-purity piping provided certain conditions are met. Reworded use of electrical flex connections in section 3.12
11-18-05	J. R. Weaver	J. R. Weaver	Changed piping nomenclature from "certified" to "tested." Certified implies quality analysis while leak testing is what is meant. Changed color code to reflect available materials. Revised information written on label.